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Planning the ERP System

Core Group Basic Training

Define the *Core Group* of personnel that will be actively involved in examining the current business processes and then helping to define an improved set of business processes using APICS prescribed ERP tools and techniques.

The Core Group needs to review the standard ERP Flowcharts for each manufacturing environment that may be applicable to your operations. It is essential that the Core Group have a basic understanding of ERP tools and techniques in order to contribute to the creation of a valid ERP Blueprint for your company.

Define Current Business Processes

The Core Group needs to define all the steps currently used to process a sale from order through delivery, and all of the steps needed to process the support functions from origination to cash payment. This is known as the order to delivery cycle and cash to cash cycle respectively.

The order to delivery cycle defines all the activities involved in getting a sales order, manufacturing the product and delivering the product to the customer.

The cash to cash cycle defines all the cash outflow activities involved with planning and providing the material, manpower and machine resources needed to manufacture the products and then paying for the resources consumed. It also defines all the cash inflow activities involved with billing for goods or services rendered and collecting receivables.

Within a single organization there may be different business process paths for different product lines or different operating divisions. Each business process path needs to be defined individually since different tools or techniques may be needed for each one.

The ERP Advisor serves as the facilitator during the creation of this outline. It is during this exercise that the Advisor develops a much better understanding of the company's operations.

Define Future Business Processes

Once the existing business processes have been defined, the ERP-educated Core Group and the ERP Advisor will retrace the business process cycles looking for opportunities to modify or automate the processes.

The key objectives are to maximize delivery performance, minimize inventory costs and maximize productivity. The latter issue affects both administrative and manufacturing productivity (maximize labor efficiency, maximize machine utilization, optimize machine setups, reduce work in process, eliminate non-value added activities, reduce unnecessary accumulation of hard copy records, etc.).

Maximizing delivery performance will delight your customers and will typically lead to increased market share and premium margins, which will *increase net income*.

Minimizing inventory will directly reduce a variety of inventory related costs (cost of capital, insurance, storage, handling, obsolescence, deterioration, spoilage, pilferage, property tax, etc.) which will *increase net income*.

Maximizing administrative productivity will reduce administrative expenses or allow for better utilization of labor resources. Maximizing manufacturing productivity will reduce product unit cost and generate better profit margins. Maximizing productivity will *increase net income*.

Documenting the ERP Blueprint

Using the information defined above, the ERP Advisor can create *Current* and *Future* ERP Flowcharts for each of the business segments outlined.

The ERP Advisor will review these Flowcharts with the Core Group to confirm that the new business process model is correct. This will become the foundation for defining and implementing specific ERP tools and techniques to each business segment.

During the implementation of the system, the ERP Blueprint is continuously updated to document the specific tools, procedures and ownership of each business process.

ERP System Budget and Schedule

Using the confirmed *Future Flowchart*, the Advisor can now more accurately define the specific hardware, software and implementation costs that will be needed to properly install and implement an ERP system for your company.

The ERP Advisor and the company can then coordinate a viable implementation schedule that meets the desired timetable for activating process improvements relative to the availability of financial and personnel resources that will be required.

The company may also want to define metrics for measuring anticipated improvements in specific areas. Improvements can be measured using delivery performance reports, inventory turns, standard costs, income statements, or a variety of other mechanisms.

Implementing the ERP System

Hardware and Software Installation

This involves making sure that an adequate computer network is in place, and installing the ERP software on the server and workstations.

A temporary training area is also highly recommended to make the learning process as efficient as possible. This usually includes at least two workstations connected to the network with access to a laser printer.

The ERP Advisor should be able to connect a laptop computer to your network in this training area, and should be able to use a computer projector in this area. A whiteboard would also be helpful.

Software Shakedown by Process

The new system will need company specific data in order to test the Future Flowchart business processes. Data from the company's legacy system may be electronically converted or manually entered into the new system.

Key members of the Core Group and the ERP Advisor need to simulate all the business processes defined by the Future Flowchart using the new ERP software tools.

The software system shakedown tests each business process to confirm that the tools will function as planned. As the desired result is confirmed for each business process the ERP tool, procedure and ownership is documented in the ERP Blueprint.

Conference Room Pilot Training

With each business process having been tested and confirmed, the ERP Blueprint now defines the individual *owners* of each process.

These operators can now be trained on the functions that are relevant to their specific area of responsibility.

Activate System and Measure Results

When the system is functional and the users are trained then it is time to begin using the new system.

As mentioned previously, metrics should be established for measuring anticipated improvements in specific areas.

ERP Related Terminology

ERP	Enterprise Resource Planning
MRP	Material Requirements Planning
MRPII	Manufacturing Resource Planning (Closed Loop MRP: MRPII with Financials)
APICS	American Production and Inventory Control Society
aka	The Educational Society for Resource Management

An **ERP System** is a set of processes that defines the optimum methods for operating a specific business to achieve maximum productivity and profitability.

An **ERP Blueprint** is the written outline for an ERP system, that details the integrated flow of processes, and assigns the individual ownership for each process.

An **ERP Software** package is the tooling that will be needed to automate some of the ERP processes. Computerization is the technology that provides the automation that allows the execution of ERP processes to be cost efficient and fast enough to be useful.

An **ERP Advisor** is the person with the experience and expertise needed to guide the efficient implementation of an ERP system.

Enterprise Resource Planning

Profitability

(income statement)

Max Customer Service

(delivery service ratio)

Min Inventory Costs

(inventory turn ratio)

Max Mfg Productivity

(actual product cost)

Manufacturing Resource Planning

MPS Master Production Planning

MRP Material Requirements Planning

CRP Capacity Requirements Planning

PAC Production Activity Control

Inventory Control and Distribution

I/M Inventory Management / DRP

S/O Sales Order Processing

P/O Purchase Order Processing

Financial Accounting and Control

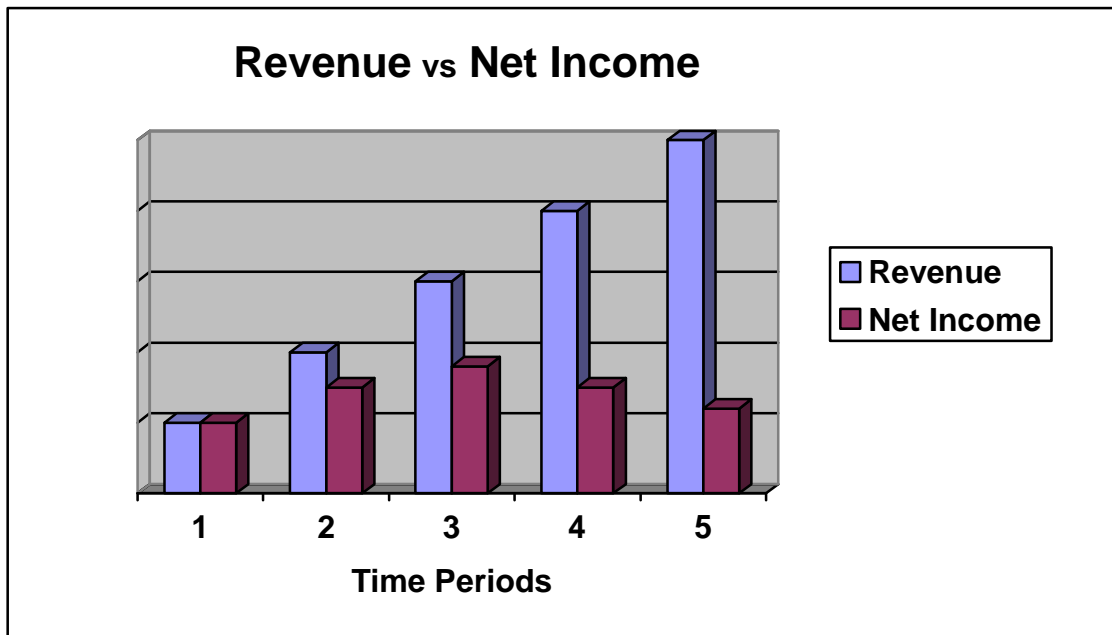
A/R
Accounts Receivable

A/P
Accounts Payable

G/L
General Ledger

The Purpose of ERP Systems

- *To improve productivity and profitability*



Reasons for lower profitability w/o ERP systems

- poor inventory control resulting in shortages and oversupplies of raw materials and finished goods
- poor material and capacity planning resulting in long lead times and late deliveries
- poor workforce planning resulting in erratic labor requirements and excessive overtime costs

Justifying an ERP System

Proven Path ERP Planning Guidelines	Top Mgmt	Project Manager	Middle Mgmt	System Operators	Class A Advisor
Assess the Viability of Installing an ERP System					
Preliminary Audit and Assessment	X		X		X
Class - Understanding ERP Principles	X		X		X
Define Corporate ERP Objectives	X		X		
Prepare Cost / Benefit Analysis	X		X		
Define Project Organization / Preliminary Planning					
Executive Steering Committee	X				
Appoint ERP Project Manager	X				
Class - Education of ERP Processes		X	X		X
Develop a Preliminary ERP Outline		X	X		X
Define Manufacturing Resource Planning Requirements					
Sales and Operations Planning	X	X			X
Demand Management / Forecasting		X	X		X
Master Production Scheduling		X	X		X
Material Requirements Planning		X	X		X
Capacity Requirements Planning		X	X		X
Production Activity Control		X	X		X
Define Inventory Management and Control Requirements					
Accurate Inventory Status		X	X		X
Accurate Inventory Data		X	X		X
Accurate Bills of Material		X	X		X
Accurate Operation Routings		X	X		X

Installing an ERP System

Proven Path ERP Planning Guidelines	Top Mgmt	Project Manager	Middle Mgmt	System Operators	Class A Advisor
Define Order Processing and Tracking Requirements					
Purchasing and Receiving		X	X		X
Sales Order Processing		X	X		X
Define Financial Accounting and Control Requirements					
Accounts Payable		X	X		X
Accounts Receivable		X	X		X
General Ledger		X	X		X
Financial Reporting	X	X	X		X
Select ERP Software to Match Requirements					
ERP Specifications Checklist		X			X
Evaluate and Select Software		X	X		X
Check Software References		X			
Automate Enterprise Resource Planning System					
Software and Hardware Installation		X			X
Software Shakedown by Process		X			X
Conference Room Pilot Training		X	X	X	X
Document Processes & Procedures		X	X	X	X
Incremental Cutover to New System		X	X	X	X
ERP Post-Implementation System Review					
Measure Results vs ERP Objectives	X	X	X		X
Followup Audit and Re-Assessment	X	X	X		X
Process Improvement (JIT and TQM)	X	X	X	X	X

The Reality and Myths of ERP

“ERP system implementation failure rates are in the range of 60 to 90 percent”

Carol Ptak
APICS President – Year 2000
Member of IBM Worldwide ERP Solutions Team

Reasons for Failure

- Lack of understanding at top management level
- Lack of education at middle management level
- Lack of training at the system operator level

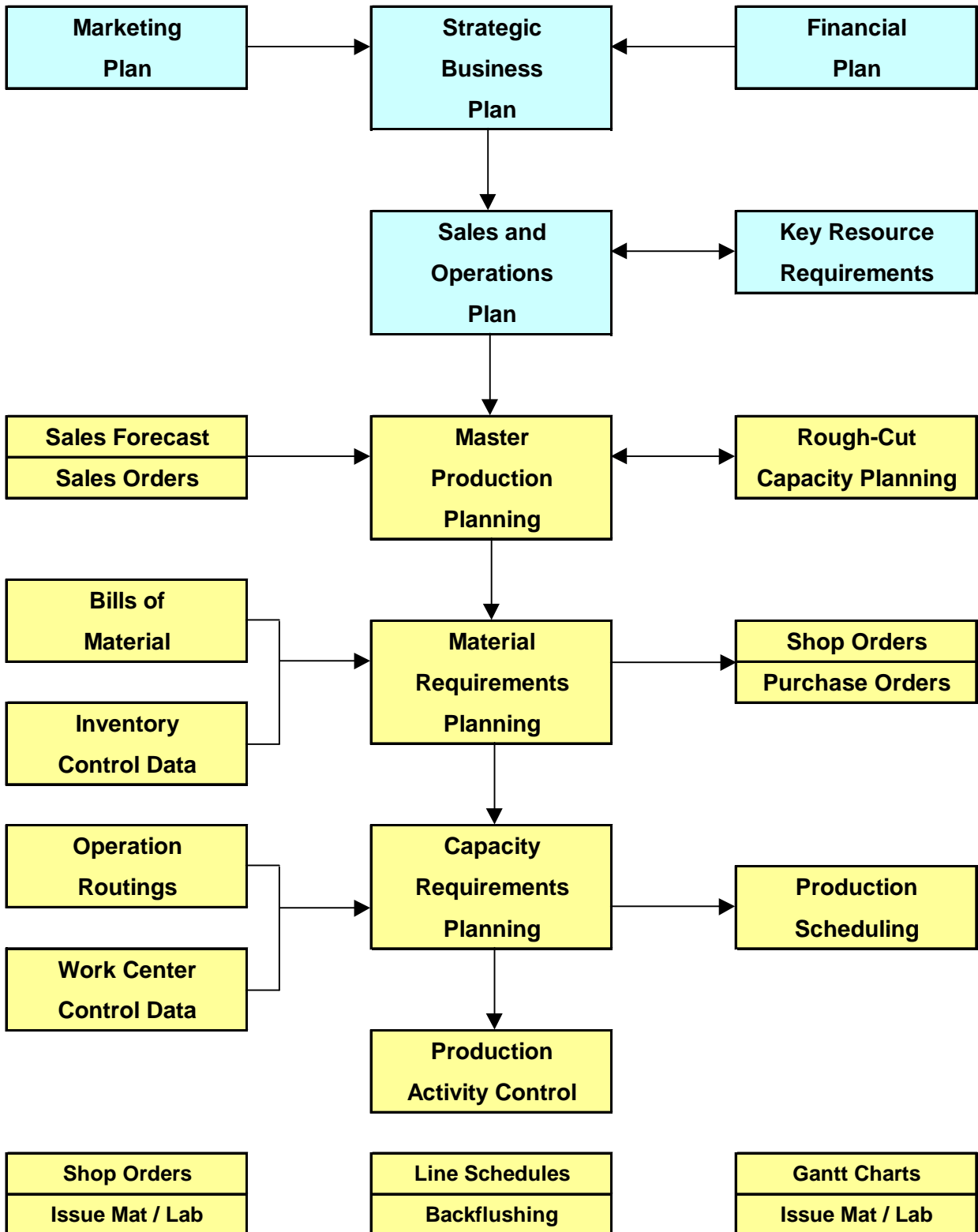
ERP Implementation Myths

- ERP software is the solution to your process problems
- There is only one ERP solution best suited to your needs
- Any ERP software system will work for your business
- Software companies are concerned with your objectives
- Most ERP resellers are competent at implementing ERP
- Firms without MIS departments can implement remotely

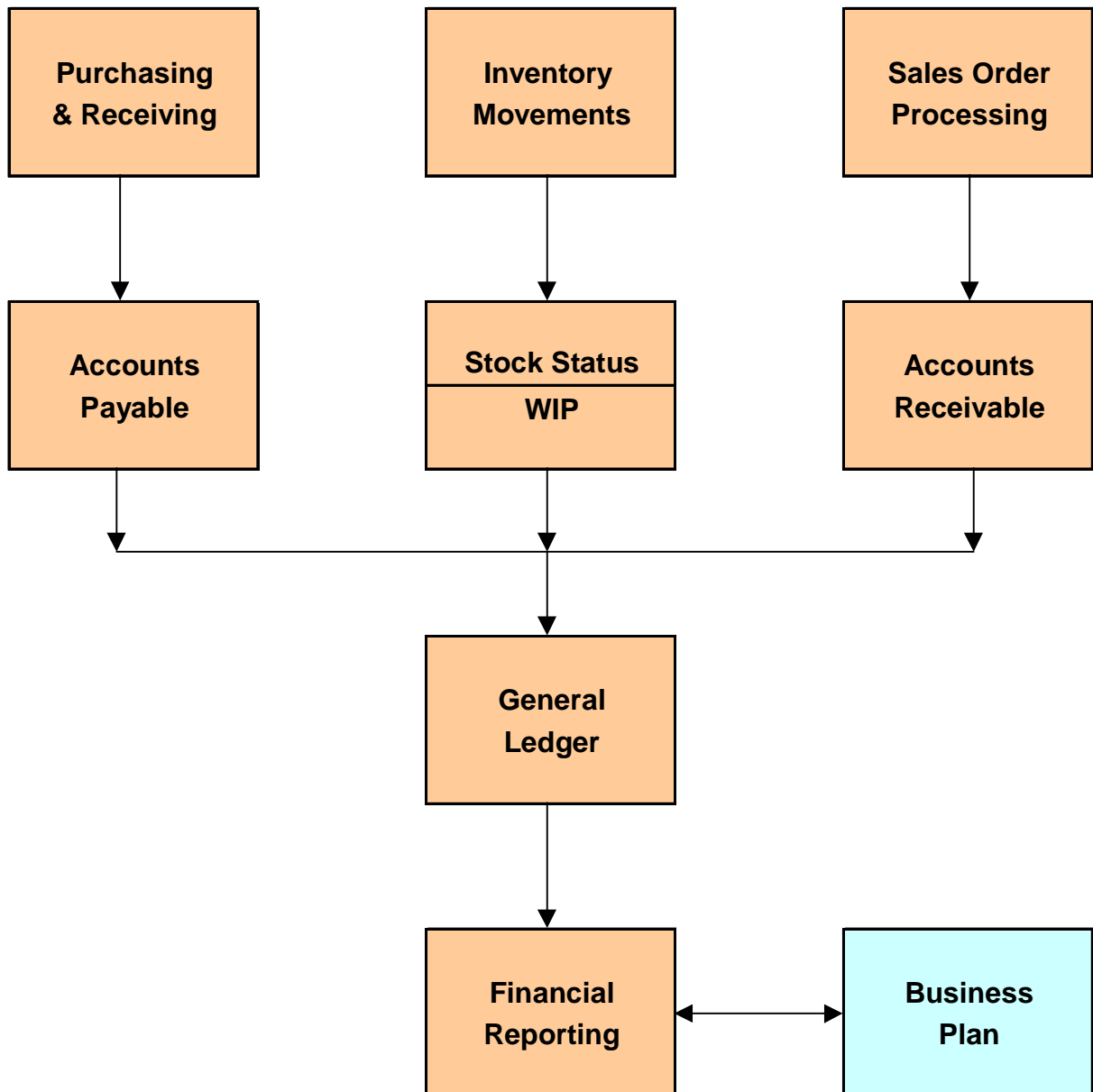
Enterprise Resource Planning is a system of people and processes that allows a manufacturing company to operate more professionally, more productively, and more profitably.

Although ERP software is important in this work, it is merely a package of tools that can be used to facilitate and automate the ERP processes.

ERP / Supply Chain Management



ERP / Supply Chain Management



Measuring Profitability

Revenue *less* Cost of Sales *less* Operating Expenses

What's in the ERP Toolbox?

ERP Tools of the Trade

- **MPS** Master Production Scheduling
- **MRP** Material Requirements Planning
- **CRP** Capacity Requirements Planning
- **PAC** Production Activity Control

Market Based Factors

- Engineer to Order
- Make to Order
- Assemble to Order
- Sell from Stock

Product Based Factors

- Unique Projects
- Batch / Job Shop
- Production Line
- Continuous Flow

Market Based Operations Planning

Engineer to Order

- design and build to customer specifications
- highly engineered / low volume production

Make to Order

- only make product after a sales orders are received
- may forecast some components to reduce lead time

Assemble to Order (Package to Order)

- modular components manufactured to a sales forecast
- final assembly schedule (FAS) used to fill sales orders

Sell from Stock

- due to delivery or batch size or capacity requirements
- product is built to a sales forecast and sold from stock
- uses master production schedule / available to promise

Product Based Operations Planning

Project Manufacturing

- engineer project / order materials / make to plan
- Critical Path / Gantt Chart for planning and control
- examples: construction, large machinery, exhibits

Batch Manufacturing

- jobs are batch routed through work departments
- MRP and CRP used to plan material and capacity
- production scheduling and load leveling required
- shop packets used for production activity control
- examples: machine shop work, laminated cutouts
- *(may also be referred to as job shop, intermittent, or batch lot manufacturing processes)*

(continued on next page)

Production Line Manufacturing

- high volume production on dedicated equipment
- components may be planned with MRP or Kanban
- uses production schedules rather than work orders
- rough cut capacity plan / forward finite scheduling
- material and labor usually posted using backflushing
- utilizes operation overlapping to reduce elapsed time
- examples: automobiles, electronics, candies
- *(may also be referred to as repetitive, flow line, flow shop, assembly line, or cellular manufacturing processes)*

Continuous Flow Manufacturing

- high volume production of liquid or non-solid product
- raw materials may be planned with MRP or Kanban
- uses production schedules rather than work orders
- rough cut capacity plan / forward finite scheduling
- material and labor usually posted using backflushing
- material flows through fixed routings (pipes, tanks)
- examples: glass, chemicals, distillers, food processors

Market and Product Linkage

Mfg Process: Project / Batch / Prod Line / Cont Flow

Market Drivers	Mfg Process	MPS	MRP	CRP	PAC
Engineer to Order					
Make to Order					
Assemble to Order					
Make to Stock					

Mfg Processes vs ERP Tooling

Categories of ERP Tools: MPS / MRP / CRP / PAC

Market Drivers	Mfg Process	MPS	MRP	CRP	PAC
Engineer to Order	Project				
Make to Order	Batch				
	Prod Line				
Assemble to Order	Batch				
	Prod Line				
Make to Stock	Batch				
	Prod Line				
	Cont Flow				

Select the Right Tools for the Job

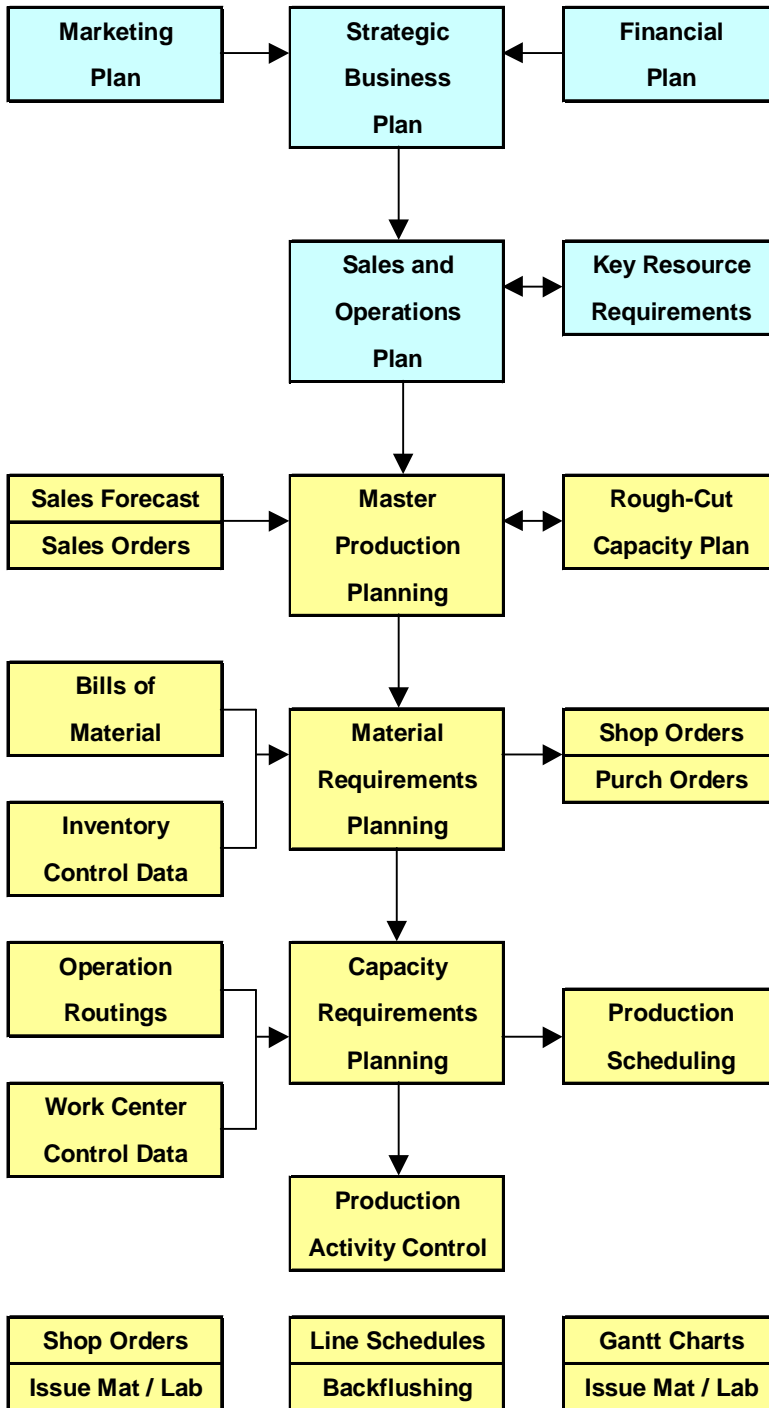
Market Drivers	Mfg Process	MPS	MRP	CRP	PAC
Engineer to Order	Project		X	Gantt	X
Make to Order	Batch		X	A	X
	Prod Line		X	B	C
Assemble to Order	Batch	X	X	A	X
	Prod Line	X	X	B	C
Make to Stock	Batch	X	X	A	X
	Prod Line	X	X	B	C
	Cont Flow	X	X	B	C

A – Backward Scheduling / Infinite Capacity

B – Finite Forward Scheduling or Rough Cut Capacity Planning

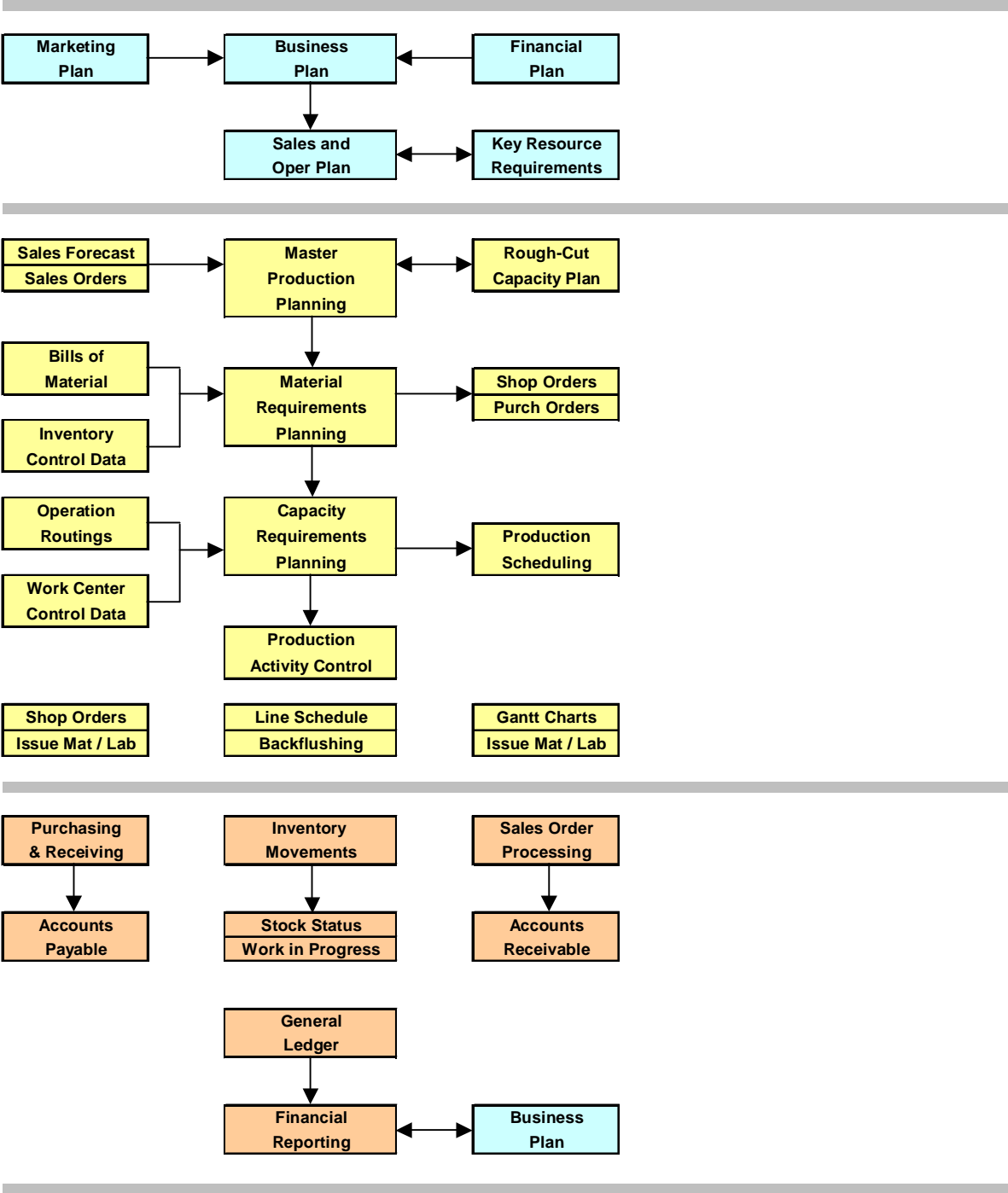
C – Backflushing Production instead of Specific Material and Labor Reporting

Resource Planning Objectives

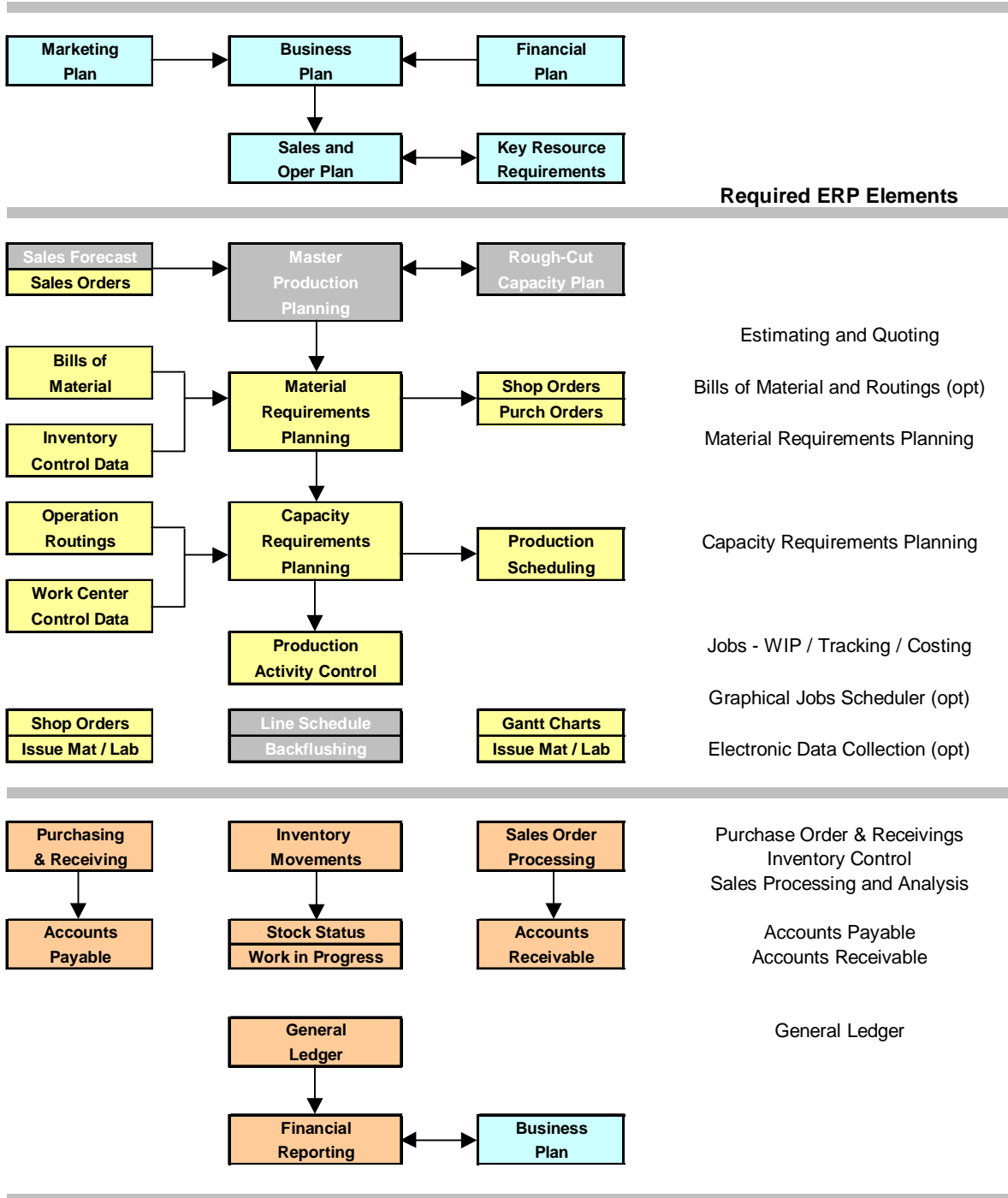


- 1 to 5 year business plan
- manpower, equipment, facilities, finance review
- 1 to 2 years by quarters
- product family groupings
- key resources required test
- 12 month plan by month
- plan end item production
- key resource capacity test
- suggests required jobs
- suggests required PO's
- time phases requirements
- suggests required actions
- plans operations for jobs
- capacity reqd vs available
- provide load leveling tools
- check material availability
- release work order packets
- generate work schedules
- issue material and labor
- job tracking / job costing

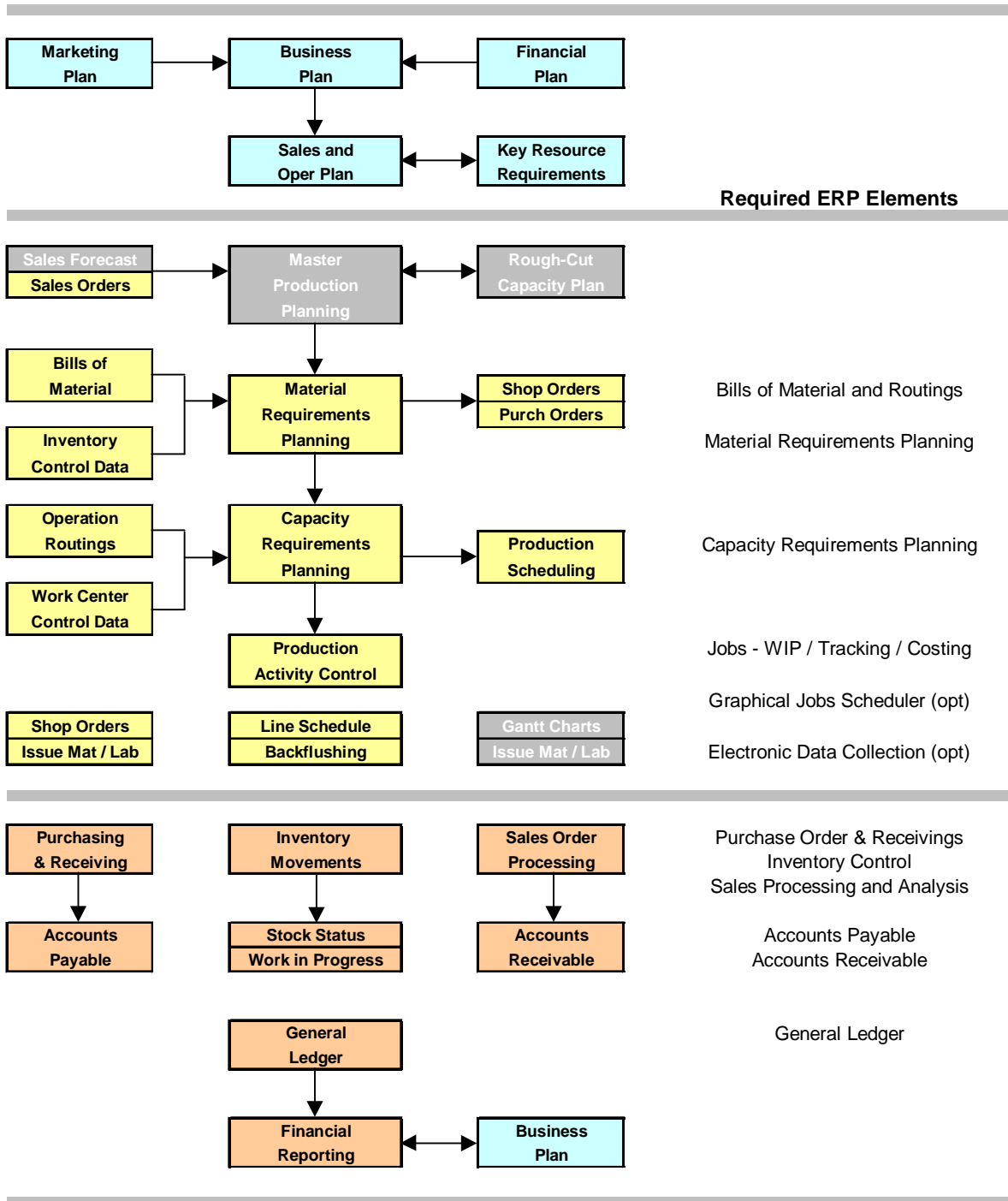
APICS Standard ERP Flowchart



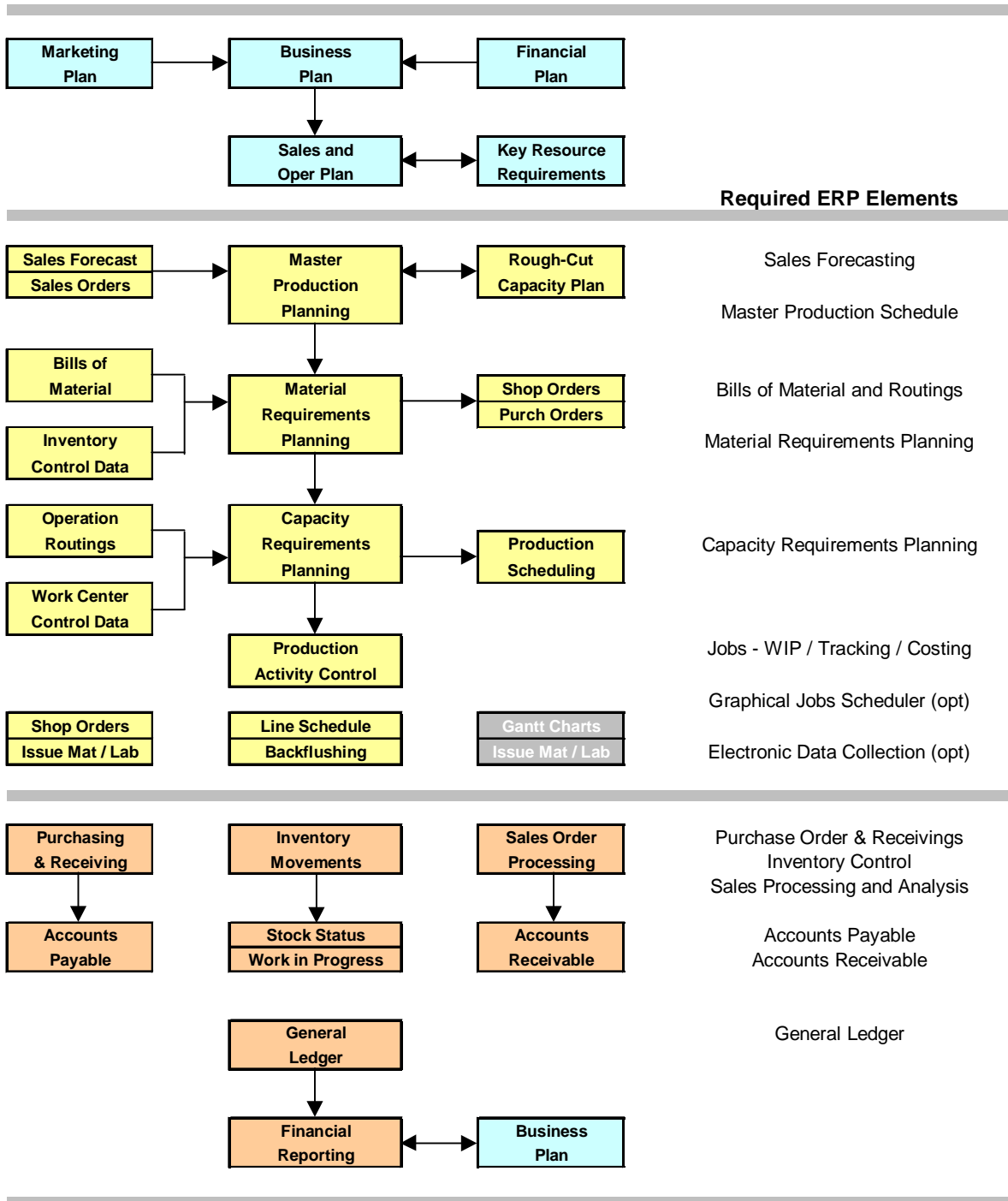
Flowchart – Engineer to Order



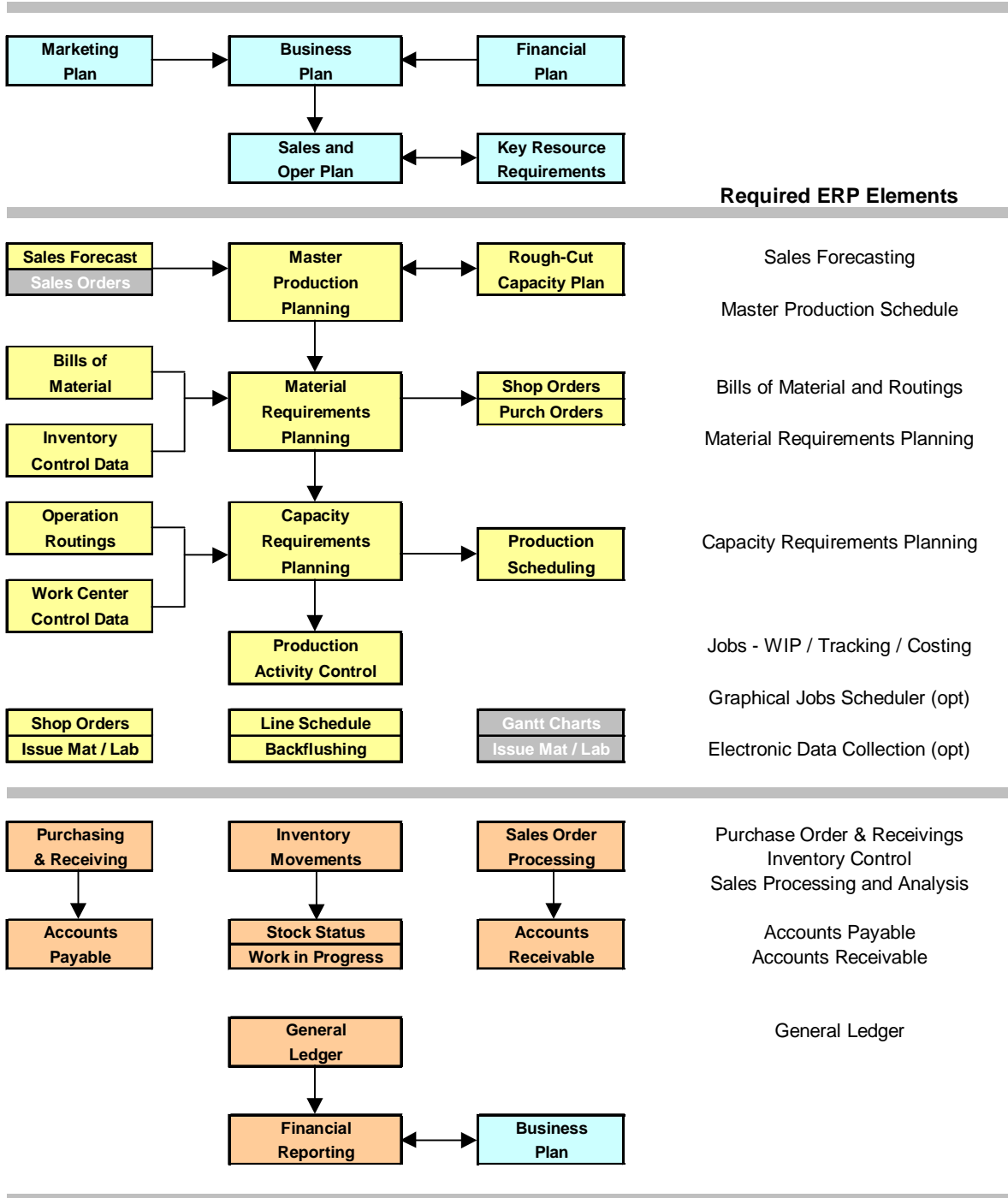
Flowchart – Make to Order



Flowchart – Assemble to Order



Flowchart – Make to Stock



Master Production Scheduling

Purpose: to plan production relative to forecasted demand

- where sales meets manufacturing via the master planner
- used where sales demand by period can be forecasted
- define build schedule by period to plan replenishment
- analyzes forecasts / sales orders / inventory / safety stock
- calc projected available balance and available to promise
- MPS (build schedule) becomes the job demand for MRP
- Rough Cut Capacity Planning checks for bottlenecks

Stock Code: 99999	Stock	P1	P2	P3	P4	P5	P6
Safety Stock = 10							
Forecasted Demand		100	100	100	100	100	100
Current Sales Orders		120	90	70	30	0	0
Gross Requirements		120	100	100	100	100	100
Build Schedule Units		100	130	200	0	200	0
Projected Avail Balance	0	-20	10	110	10	110	10
Available to Promise		-20	40	100	100	200	200
Suggested Adjustments		30	0	0	0	0	0

- **PAB** = (prior PAB) + (Build Schedule) – (Gross Reqmts)
- **ATP** = (Stock or Build) – (Sales Orders prior to next Build)
- **ADJ** = (Safety Stock) – (Projected Available Balance) [>0]

Production Planning Exercises

Stock Code: 99999	Stock	P1	P2	P3	P4	P5	P6
Safety Stock = 10							
Forecasted Demand		100	100	100	100	100	100
Current Sales Orders		120	90	70	30	0	0
Gross Requirements		120	100	100	100	100	100
Build Schedule Units		100	130	200	0	200	0
Projected Avail Balance	0						
Available to Promise							
Suggested Adjustments							

Stock Code: 99999	Stock	P1	P2	P3	P4	P5	P6
Safety Stock = 0							
Forecasted Demand		100	100	100	100	100	100
Current Sales Orders		50	45	30	20	5	0
Gross Requirements							
Build Schedule Units							
Projected Avail Balance	40						
Available to Promise							
Suggested Adjustments							

Stock Code: 99999	Stock	P1	P2	P3	P4	P5	P6
Safety Stock = 50							
Forecasted Demand		100	200	300	300	100	0
Current Sales Orders		80	120	40	20	0	0
Gross Requirements							
Build Schedule Units		50	400	200	0	0	0
Projected Avail Balance	70						
Available to Promise							
Suggested Adjustments							

Production Planning Answers

Stock Code: 99999	Stock	P1	P2	P3	P4	P5	P6
Safety Stock = 10							
Forecasted Demand		100	100	100	100	100	100
Current Sales Orders		120	90	70	30	0	0
Gross Requirements		120	100	100	100	100	100
Build Schedule Units		100	130	200	0	200	0
Projected Avail Balance	0	-20	10	110	10	110	10
Available to Promise		-20	40	100		200	
Suggested Adjustments		30	0	0	0	0	0

Stock Code: 99999	Stock	P1	P2	P3	P4	P5	P6
Safety Stock = 0							
Forecasted Demand		100	100	100	100	100	100
Current Sales Orders		50	45	30	20	5	0
Gross Requirements		100	100	100	100	100	100
Build Schedule Units		60	100	100	100	100	100
Projected Avail Balance	40	0	0	0	0	0	0
Available to Promise		50	55	70	80	95	100
Suggested Adjustments		0	0	0	0	0	0

Stock Code: 99999	Stock	P1	P2	P3	P4	P5	P6
Safety Stock = 50							
Forecasted Demand		100	200	300	300	100	0
Current Sales Orders		80	120	40	20	0	0
Gross Requirements		100	200	300	300	100	0
Build Schedule Units		50	400	200	0	0	0
Projected Avail Balance	70	20	220	120	-180	-280	-280
Available to Promise		40	280	140			
Suggested Adjustments		30	-170	-70	230	330	330

MPS Usage Considerations

Time Fences

- ***Demand time fence:*** near term period within which changes to MPS are kept to a minimum to avoid disruption to the production schedule
- ***Planning time fence:*** the longest cumulative lead time (purchasing lead time + manufacturing lead time) for the stock code
- ***Planning horizon:*** the time period to consider when processing MRP to properly incorporate batching rules

Input to MRP

- the Build Schedule quantity becomes the sole demand quantity to MRP for each MPS stock code item
- existing stock, safety stock, forecasts and sales orders are ignored by MRP for MPS stock code items
- MRP needs only to consider current existing jobs when calculating the need for new jobs for MPS items
- as production is reported against jobs for MPS items, the Build Schedule quantity is reduced and current stock is increased (keeps PAB in sync with the Master Schedule)
- as sales orders are invoiced the forecast, sales orders and stock quantities are consumed (keep gross requirements, PAB and ATP in sync with the Master Schedule)

Anatomy of Product Structures

Product Structures are the sequence of operations that components follow during their manufacture into a product.

Parent Item: **TABLE**

Qty 1

Work Center	Capacity (hrs/day)	Unit (hrs/pc)	Batch (pcs/time)	Rate (pcs/hr)	Cost (\$/hr)	Queue (hrs)
Cutting	8				\$25.00	8
Planing	8				\$35.00	4
Sanding	8				\$20.00	4
Drilling	8				\$40.00	4
Finishing	8		3 / 90 min		\$50.00	8
Assembly	8			5 per hr	\$20.00	4

Operations	Setup (hrs)	Startup (hrs)	Run (hrs)	Teardown (hrs)	Wait (hrs)	Move (hrs)
Cutting						
Planing						
Sanding						
Drilling						
Finishing	0.5	0	0.5	0.5	24	1
Assembly	0	0	0.2	0	0	0.5

Components	Stock Code	Sequence Number	Part Category	Quantity Required	Linked to Operation	Scrap (% or qty)
26" x 40" x 1.5" top	TOP	1	Made-in	1 ea	Finishing	0%
2" x 2" x 36" legs	LEG	2	Made-in	4 ea	Finishing	0%
clear urethane finish	CLEAR	3	Purchased	10 oz	Finishing	15%
1/2" x 3" carriage bolt	BOLT	4	Purchased	8 ea	Assembly	5%

Anatomy of Sub-Assembly #1

Sub-Assembly: **TOP**

Qty 1

Work Center	Capacity (hrs/day)	Unit (hrs/pc)	Batch (pcs/time)	Rate (pcs/hr)	Cost (\$/hr)	Queue (hrs)
Cutting	8	0.75			\$25.00	8
Planing	8	0.5			\$35.00	4
Sanding	8	2			\$20.00	4
Drilling	8	0.85			\$40.00	4
Finishing	8				\$50.00	8
Assembly	8				\$20.00	4

Operations	Setup (hrs)	Startup (hrs)	Run (hrs)	Teardown (hrs)	Wait (hrs)	Move (hrs)
Cutting	0.25	0	0.75	0.1	0	0.5
Planing	0.25	0	0.5	0.1	0	0.5
Sanding	0	0	2	0.1	0	0.5
Drilling	0.25	0	0.85	0.1	0	0.5
Finishing						
Assembly						

Components	Stock Code	Sequence Number	Part Category	Quantity Required	Linked to Operation	Scrap (% or qty)
30" x 48" x 2" oak	T-OAK	1	Purchased	1 ea	Cutting	10%

Anatomy of Sub-Assembly #2

Sub-Assembly: **LEG**

Qty 4

Work Center	Capacity (hrs/day)	Unit (hrs/pc)	Batch (pcs/time)	Rate (pcs/hr)	Cost (\$/hr)	Queue (hrs)
Cutting	8	0.5			\$25.00	8
Planing	8	0.3			\$35.00	4
Sanding	8	0.8			\$20.00	4
Drilling	8	0.25			\$40.00	4
Finishing	8				\$50.00	8
Assembly	8				\$20.00	4

Operations	Setup (hrs)	Startup (hrs)	Run (hrs)	Teardown (hrs)	Wait (hrs)	Move (hrs)
Cutting	0.25	0	2	0.1	0	0.5
Planing	0.25	0	1.2	0.1	0	0.5
Sanding	0	0	3.2	0.1	0	0.5
Drilling	0.25	0	1	0.1	0	0.5
Finishing						
Assembly						

Components	Stock Code	Sequence Number	Part Category	Quantity Required	Linked to Operation	Scrap (% or qty)
3" x 3" x 40" oak	L-OAK	1	Purchased	1 ea	Cutting	20%

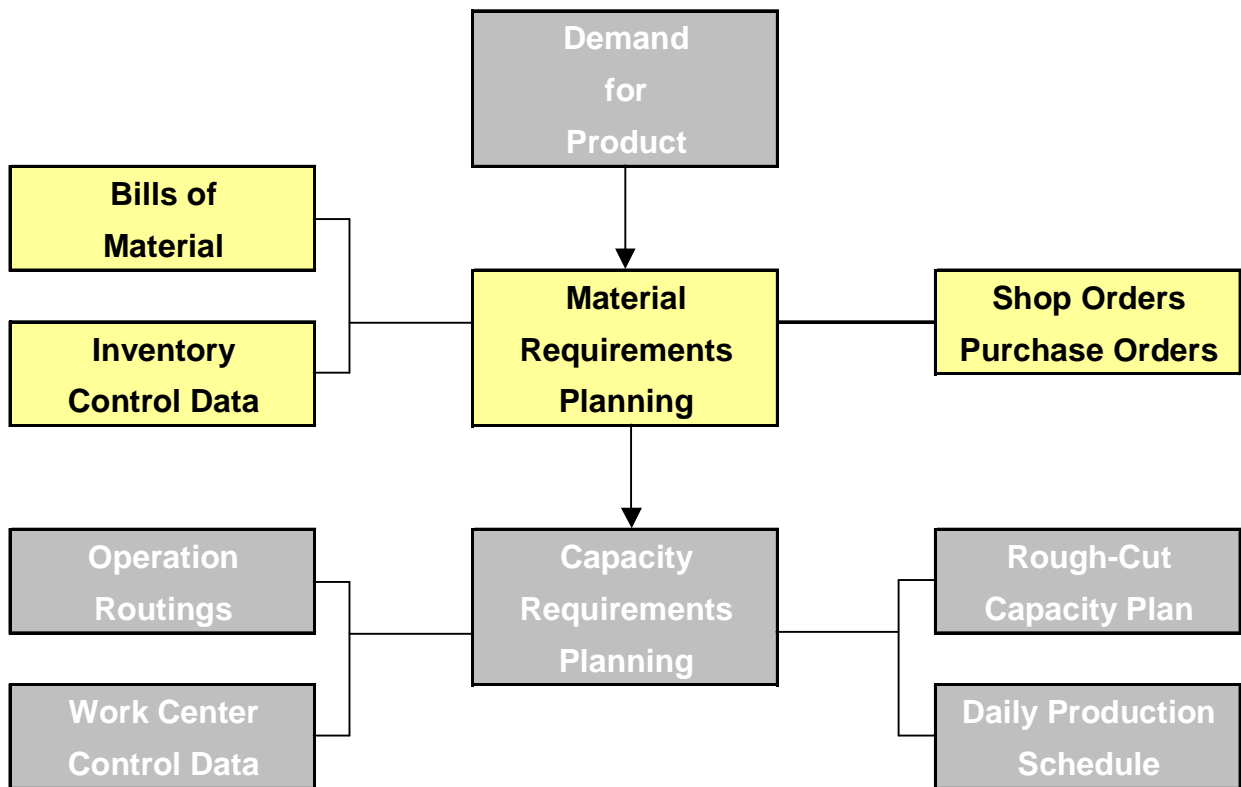
Single Level Product Structure

Parent Item: **TABLE**

Qty 1

Operations (Top)	Setup (hrs)	Startup (hrs)	Run (hrs)	Teardown (hrs)	Wait (hrs)	Move (hrs)
Cutting	0.25	0	0.75	0.1	0	0.5
Planing	0.25	0	0.5	0.1	0	0.5
Sanding	0	0	2	0.1	0	0.5
Drilling	0.25	0	0.85	0.1	0	0.5
Operations (Legs)	Setup (hrs)	Startup (hrs)	Run (hrs)	Teardown (hrs)	Wait (hrs)	Move (hrs)
Cutting	0.25	0	2	0.1	0	0.5
Planing	0.25	0	1.2	0.1	0	0.5
Sanding	0	0	3.2	0.1	0	0.5
Drilling	0.25	0	1	0.1	0	0.5
Operations (Table)	Setup (hrs)	Startup (hrs)	Run (hrs)	Teardown (hrs)	Wait (hrs)	Move (hrs)
Finishing	0.5	0	0.5	0.5	24	1
Assembly	0	0	0.2	0	0	0.5
Components	Stock Code	Sequence Number	Part Category	Quantity Required	Linked to Operation	Scrap (% or qty)
30" x 48" x 2" oak	T-OAK	1	Purchased	1 ea	Cutting	10%
3" x 3" x 40" oak	L-OAK	2	Purchased	4 ea	Cutting	20%
clear urethane finish	CLEAR	3	Purchased	10 oz	Finishing	15%
1/2" x 3" carriage bolt	BOLT	4	Purchased	8 ea	Assembly	5%

Material Requirements Planning



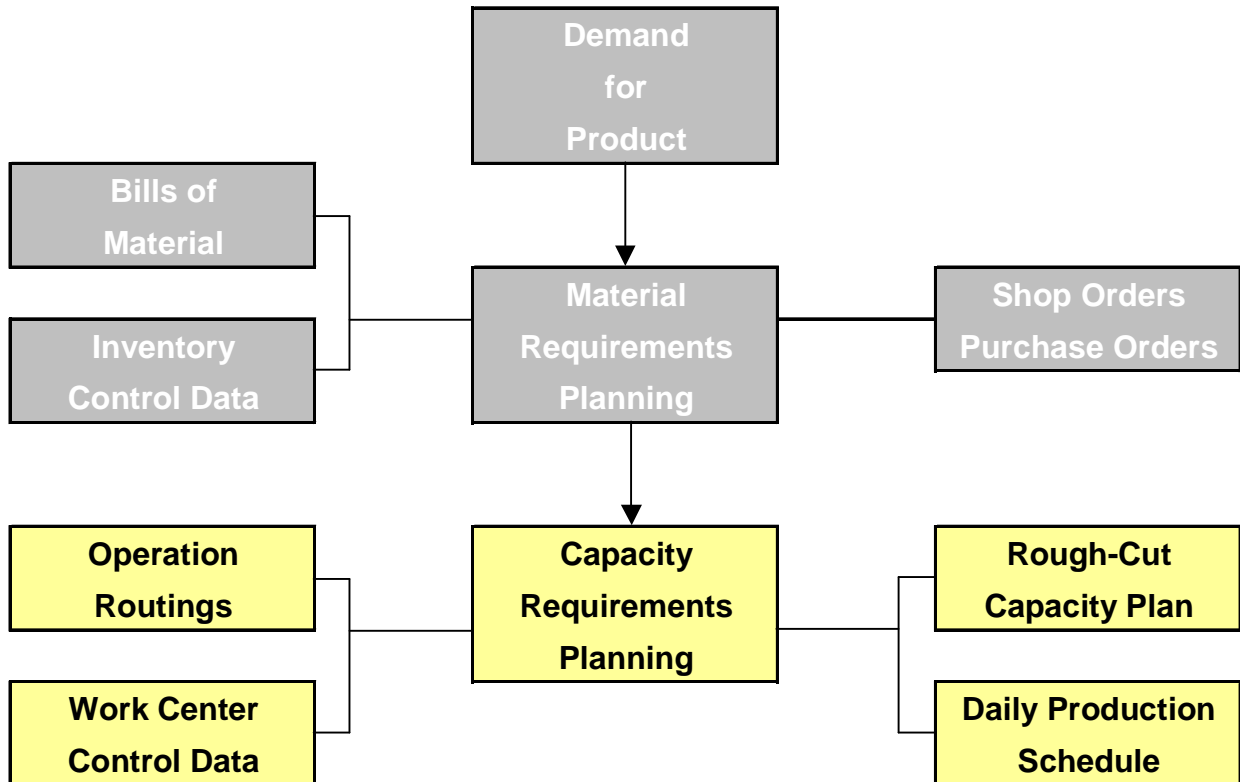
Purpose of MRP

- recommend new jobs and provide a calculated start date
- recommend job actions due to demand / supply changes
- recommend time-phased purchase orders to supply jobs
- recommend P/O actions due to demand / supply changes

MRP Input / Calculation / Output

Inputs	Processing	Outputs
<p data-bbox="250 474 548 510">Independent Demand</p> <ul data-bbox="228 548 545 863" style="list-style-type: none"> • MPS Build Schedule • Sales Orders • Sales Forecasts • Sales Quotations • Safety Stock <p data-bbox="261 913 537 949">Dependent Demand</p> <ul data-bbox="228 984 553 1161" style="list-style-type: none"> • Made-in components • Sub-contract work • Purchase components <p data-bbox="289 1209 509 1245">Inventory Rules</p> <ul data-bbox="228 1281 565 1528" style="list-style-type: none"> • Made or purchased • Batch sizing by item • Lead times by item • 95% accuracy required <p data-bbox="289 1577 509 1612">Bills of Material</p> <ul data-bbox="228 1648 565 1824" style="list-style-type: none"> • Components required • Include scrap factors • 99% accuracy required 	<p data-bbox="716 474 959 510">MRP Calculation</p> <ul data-bbox="667 548 1003 930" style="list-style-type: none"> • Regen or Net-Change • Calc demand for Jobs • Demand for Sub-Jobs • Sub-contract demand • Demand for Purchases 	<p data-bbox="1143 474 1393 510">Orders & Reports</p> <ul data-bbox="1105 680 1414 1654" style="list-style-type: none"> è Manufacturing Jobs è Manufacturing Jobs è Purchase Orders è Purchase Orders • Job Review • Job Actions report • P/O Review • P/O Actions report • MRP Details report • Pegging by Item • Potential Oversupply

Capacity Requirements Planning



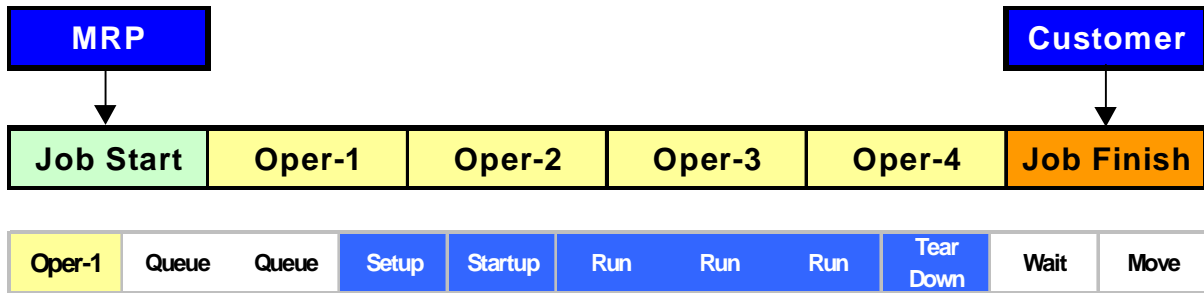
Purpose of CRP

- calc work center operation start / finish dates by job
- use rough-cut capacity loading to plan resource levels
- compare capacity required vs available by work center
- load leveling (adjust capacity, reschedule, sub-contract)

CRP Input / Calculation / Output

Inputs	Processing	Outputs
<p data-bbox="269 510 532 541">Sources of Demand</p> <ul data-bbox="232 583 467 751" style="list-style-type: none"> • Active jobs • Suggested jobs • Probable jobs <p data-bbox="305 888 500 919">Work Centers</p> <ul data-bbox="232 961 537 1203" style="list-style-type: none"> • Capacity calendar • Overtime factors • Productivity factor • Labor / burden rates <p data-bbox="337 1339 467 1371">Routings</p> <ul data-bbox="232 1413 557 1623" style="list-style-type: none"> • Define operations • Define work centers • Define queue, setup, run, wait, move times 	<p data-bbox="732 510 951 541">CRP Processing</p> <ul data-bbox="670 646 1008 1528" style="list-style-type: none"> • Calc operation start and finish dates by job • Aggregate capacity requirements by day and by work center • Compare required capacity vs available for each work center • Identify overloaded work centers • Resolve work center overloads using load leveling tools 	<p data-bbox="1138 510 1406 541">Balanced Schedules</p> <ul data-bbox="1109 835 1425 1717" style="list-style-type: none"> è Rough-cut capacity loading report used to plan resources or to revise demand è Dispatch lists by work center è Balanced labor force daily requirements è Balanced daily work center loading

CRP – Operation Lead Time



Queue

staging buffer time

Setup

machine preparation

Startup

starting production

Run

produce good product

Teardown

shutdown, cleaning

Wait

drying, curing, cooling

Move

to next operation

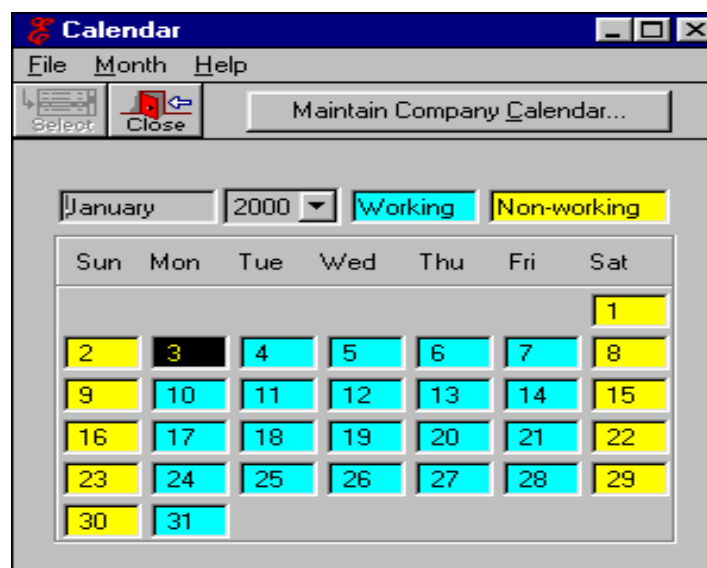
Oper	Queue	Setup	Startup	Run	Tear Down	Wait	Move	InterOp Hours	CapReq Hours	Lead Time
1	24	1	1	10	0	0	0	24	12	1 + 1.5
2	8	2	0	5	1	4	4	16	8	.7 + 1
3	2	2.5	0.5	15	1.5	0	2	4	19.5	.2 + 2.4
4	16	2	0	6.5	0.5	1	1	18	9	.8 + 1.1

Operation Time: inter-operation time *plus* work center time (days)

Job Lead Time Offset: days required between job start and finish dates based on the **Operation Lead Times** and the **Shop Calendar**

CRP – Job Lead Time Offset

Job 100	Job Start	Oper-1	Oper-2	Oper-3	Oper-4	Job Finish
Operation Lead Times	MRP	3 days	2 days	3 days	2 days	Customer
Backward Scheduling	06-Jan	6 + 7 + 10	11 + 12	13 + 14 + 17	18 + 19	20-Jan
Forward Scheduling	04-Jan	4 + 5 + 6	7 + 10	11 + 12 + 13	14 + 17	18-Jan



Compressing Job Lead Time Offset

- operation overlap (start Oper-2 while Oper-1 running)
- reduce queue, setup, startup, run, teardown, wait, move
- optimize job scheduling to reduce redundant setups

The benefits of reducing manufacturing lead times for jobs include less work in process, less raw material inventory, less finished goods inventory, faster service to the customer, increased sales and increased market share.

Calculating Capacity Required

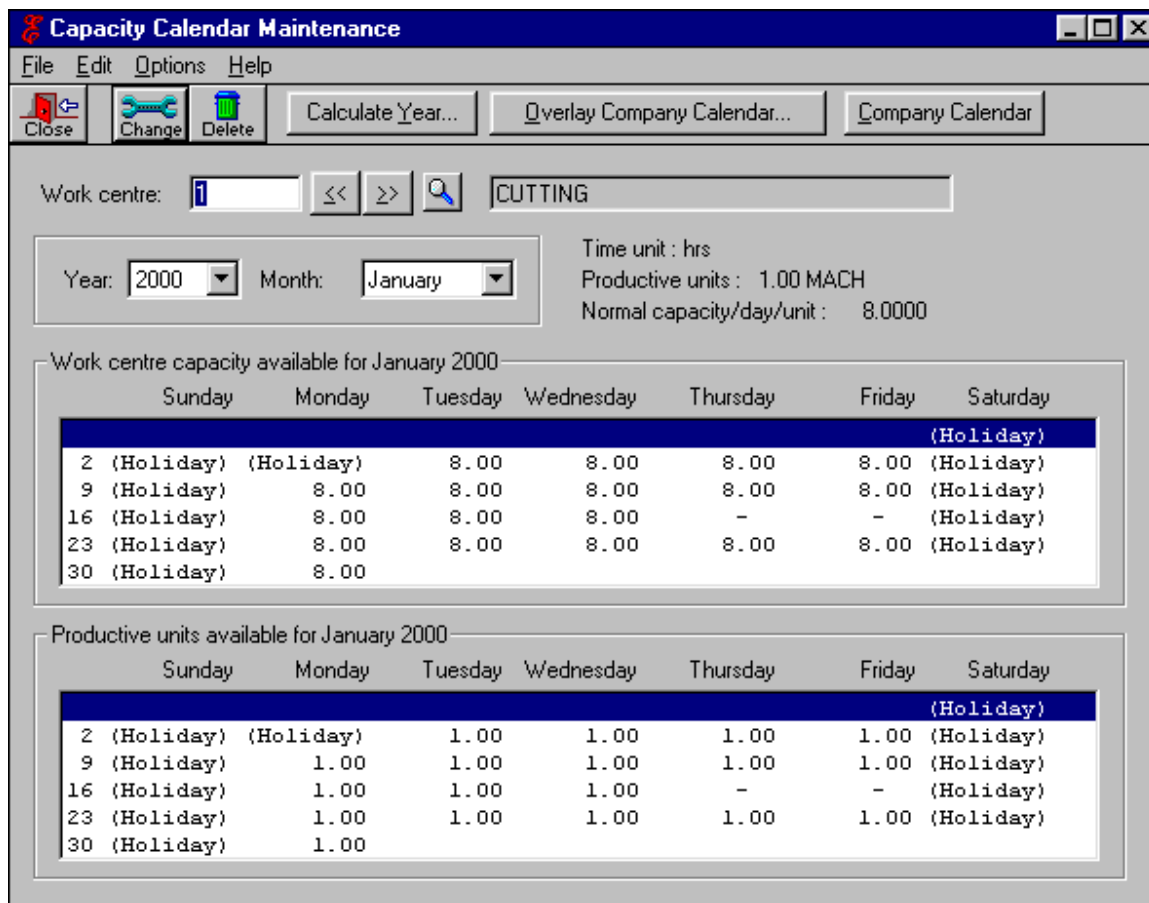
Work Centers - capacity planning entities

- similar machines in a department (five drill presses)
- work cell in-line machines for making specific products
- routing specific resource (CNC Acme Model 99 press)

Job	Job Start	W/c-1	W/c-2	W/c-3	W/c-4	Job Finish
100	06-Jan	7 + 10	12	13 + 14 + 17	18 + 19	20-Jan
	Cap Req ->	12	8	19.5	9	
200	17-Jan	17		18	19	20-Jan
	Cap Req ->	2		6	3	
300	14-Jan		14	17 + 18	19 + 20	21-Jan
	Cap Req ->		6	12	14	
400	17-Jan	18	19	20	21	24-Jan
	Cap Req ->	6	4	4	6	

W/c-3	Sun	Mon	Tue	Wed	Thu	Fri	Sat
Capacity	02-Jan	03-Jan	04-Jan	05-Jan	06-Jan	07-Jan	08-Jan
Available		8	8	8	8	8	
Required							
Capacity	09-Jan	10-Jan	11-Jan	12-Jan	13-Jan	14-Jan	15-Jan
Available		8	8	8	8	8	
Required					8	8	
Capacity	16-Jan	17-Jan	18-Jan	19-Jan	20-Jan	21-Jan	22-Jan
Available		8	8	8	8	8	
Required		3.5 + 8	6 + 4		4		

Work Center Capacity Calendar

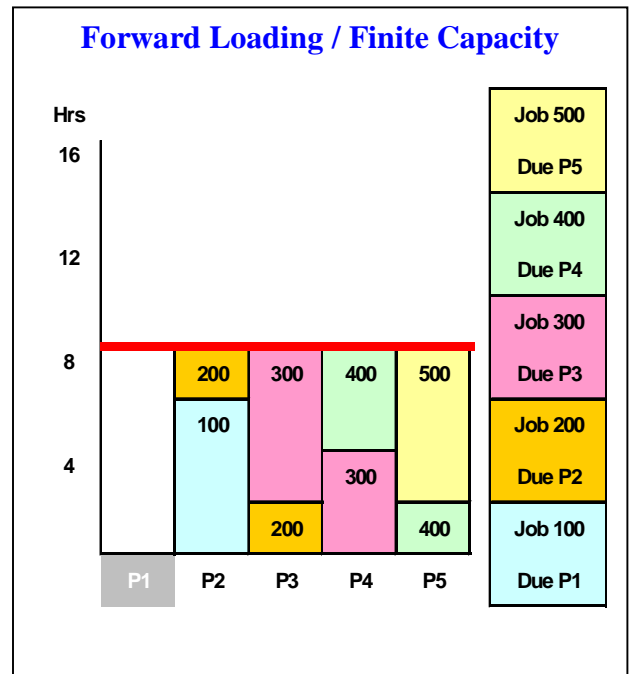
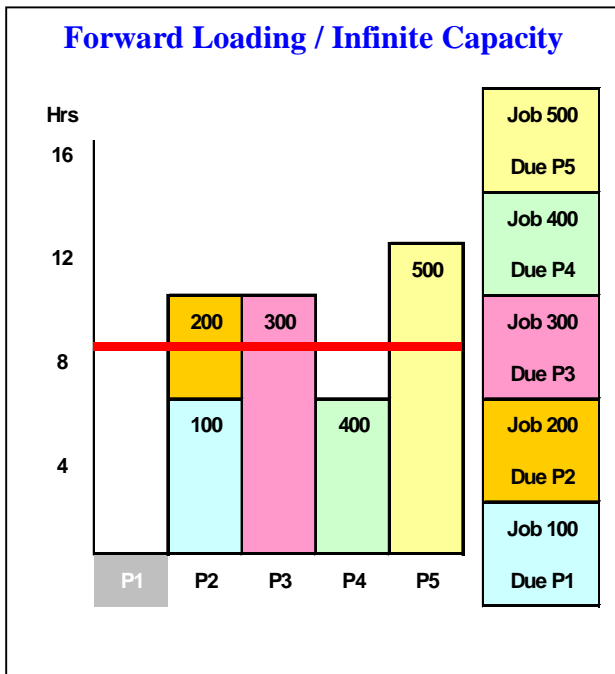
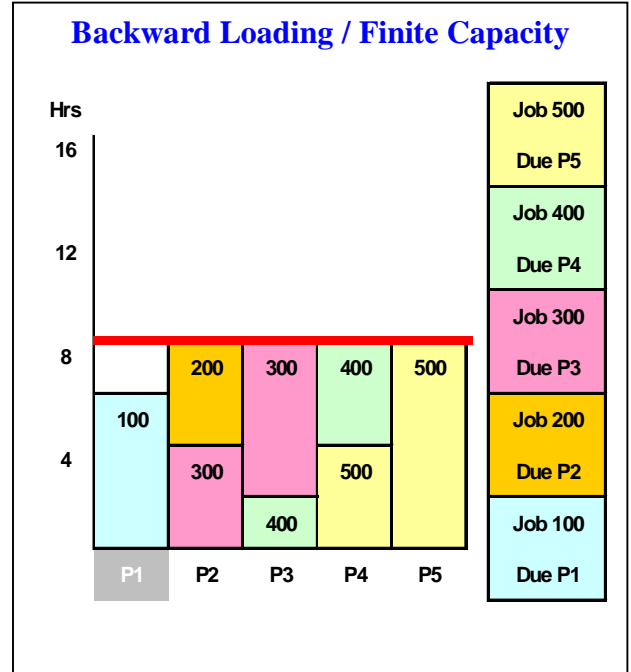
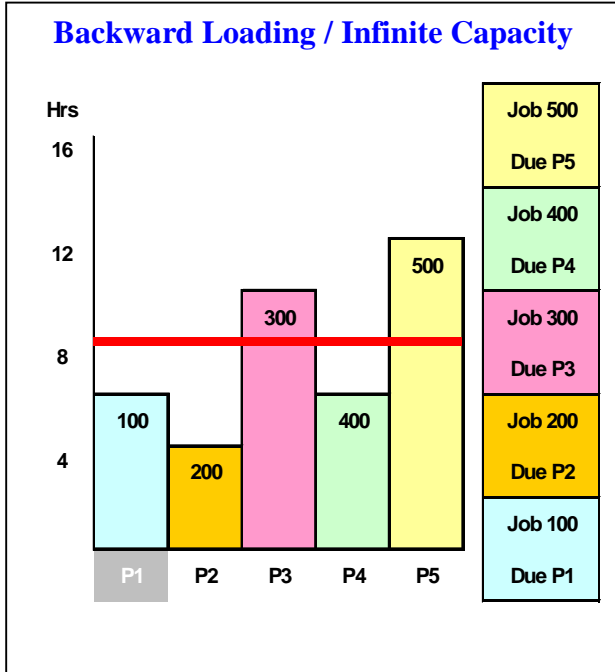


Capacity is defined as the capability of a work center to perform a specific amount of work on a specific day.

Capacity Calendar Features

- overlay company calendar to define non-working days
- define work center capacities for each active work day
(productive units x daily capacity x utilization factor x efficiency factor)
- specify work center downtime or reduced capacity days

Work Center Loading Techniques



Work Center Loading Definitions

Loading is defined as the work that is scheduled to be performed at a work center on a specific day.

Backward Loading / Infinite Capacity

- typical scheduling technique for batch processing where multiple work centers may be required for any job and where capacity constraints may exist at one or more of the work centers on any specific work day
- use load leveling techniques to adjust capacity and / or operation start/stop schedule dates to balance workloads

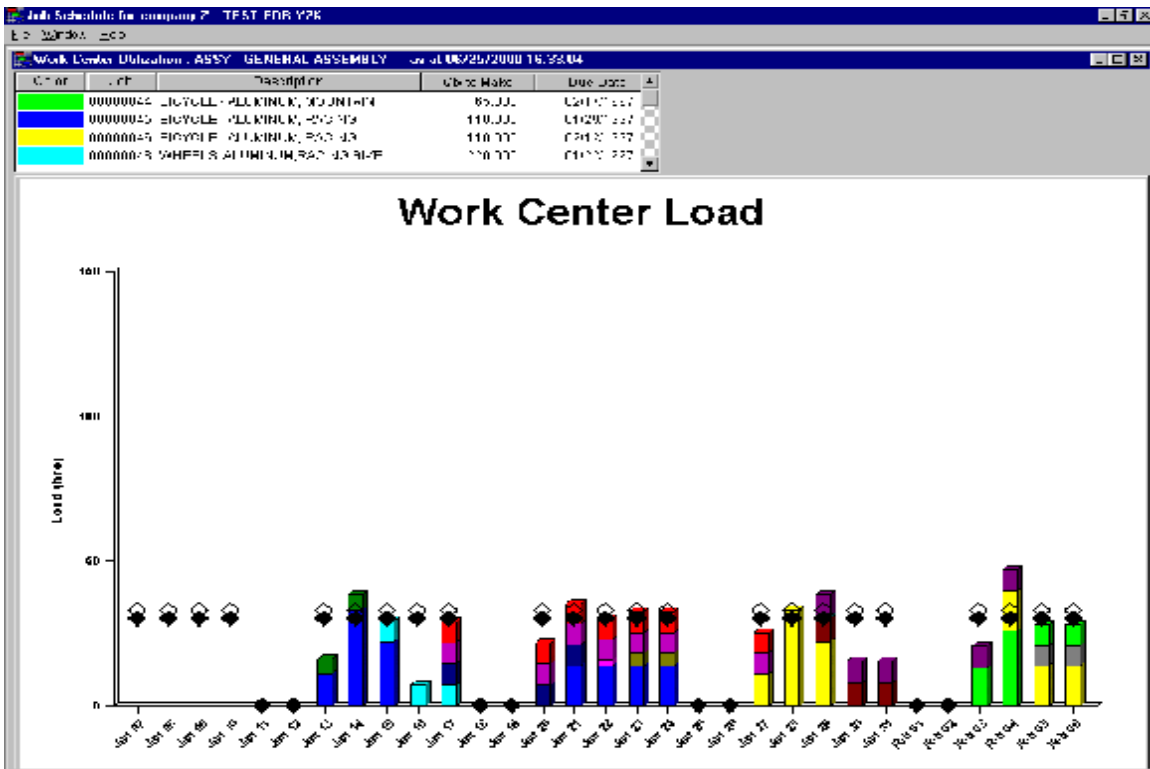
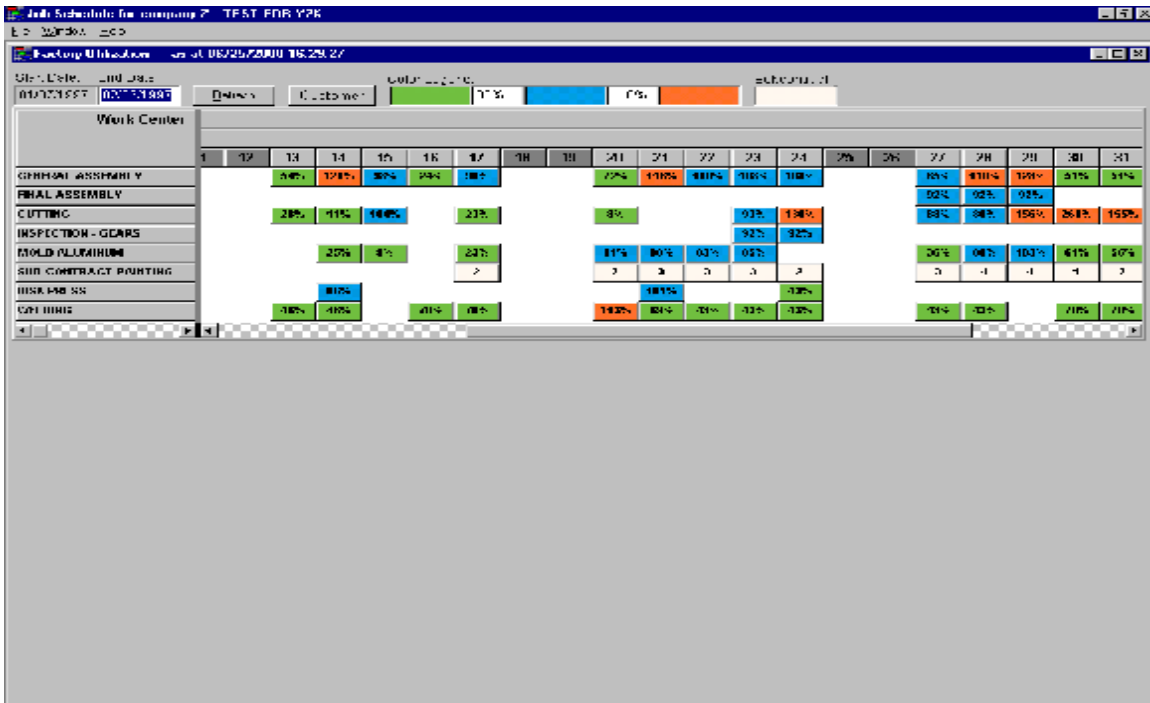
Forward Loading / Finite Capacity

- typical scheduling technique for in-line processes where production routing is contained within a single work cell
- computes job schedule dates based on order backlog and the rated line capacity to generate a production schedule
- provides good what-if capacity testing for batch process orders where a sales order opportunity exists conditional upon order delivery in less than the normal lead time

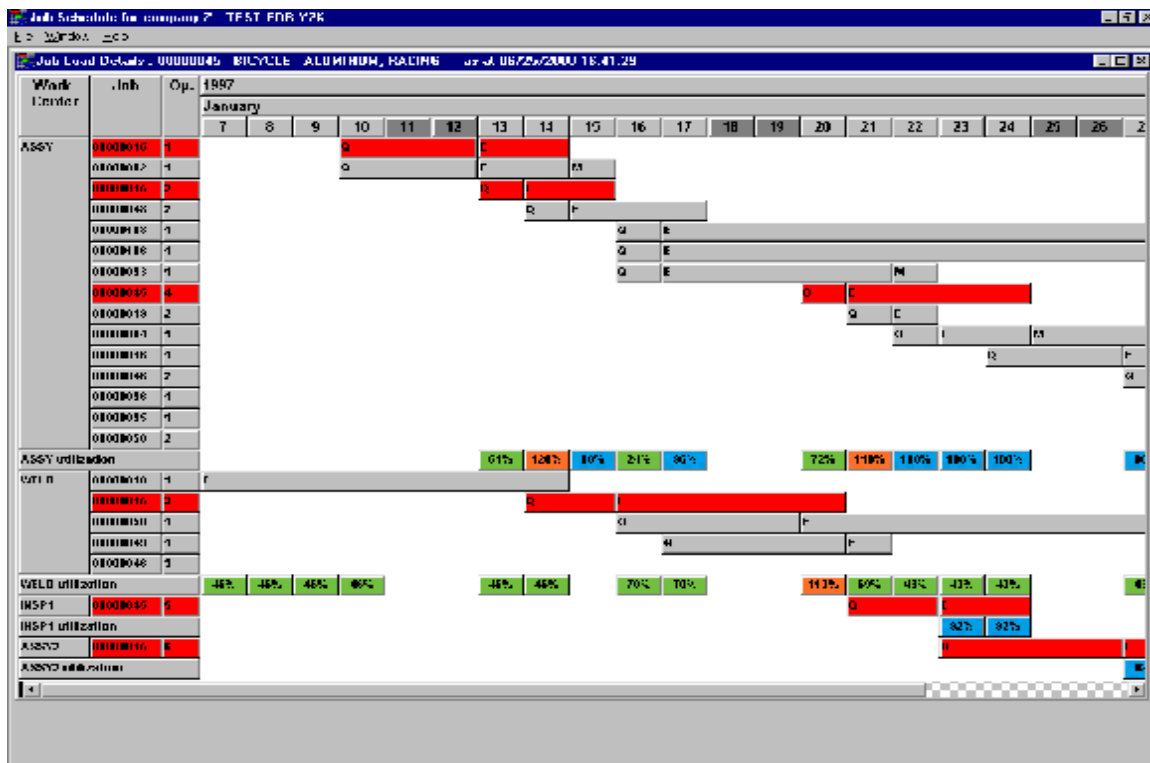
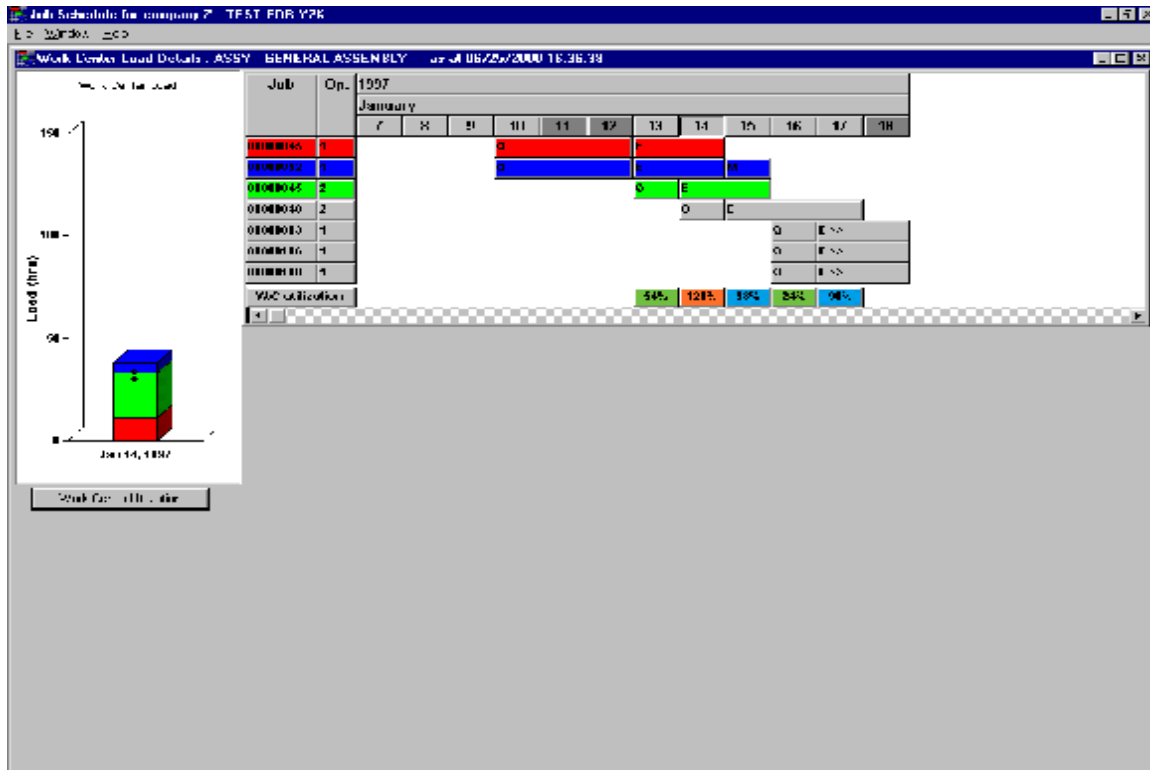
Backward Loading / Finite Capacity (not commonly used)

Forward Loading / Infinite Capacity (not commonly used)

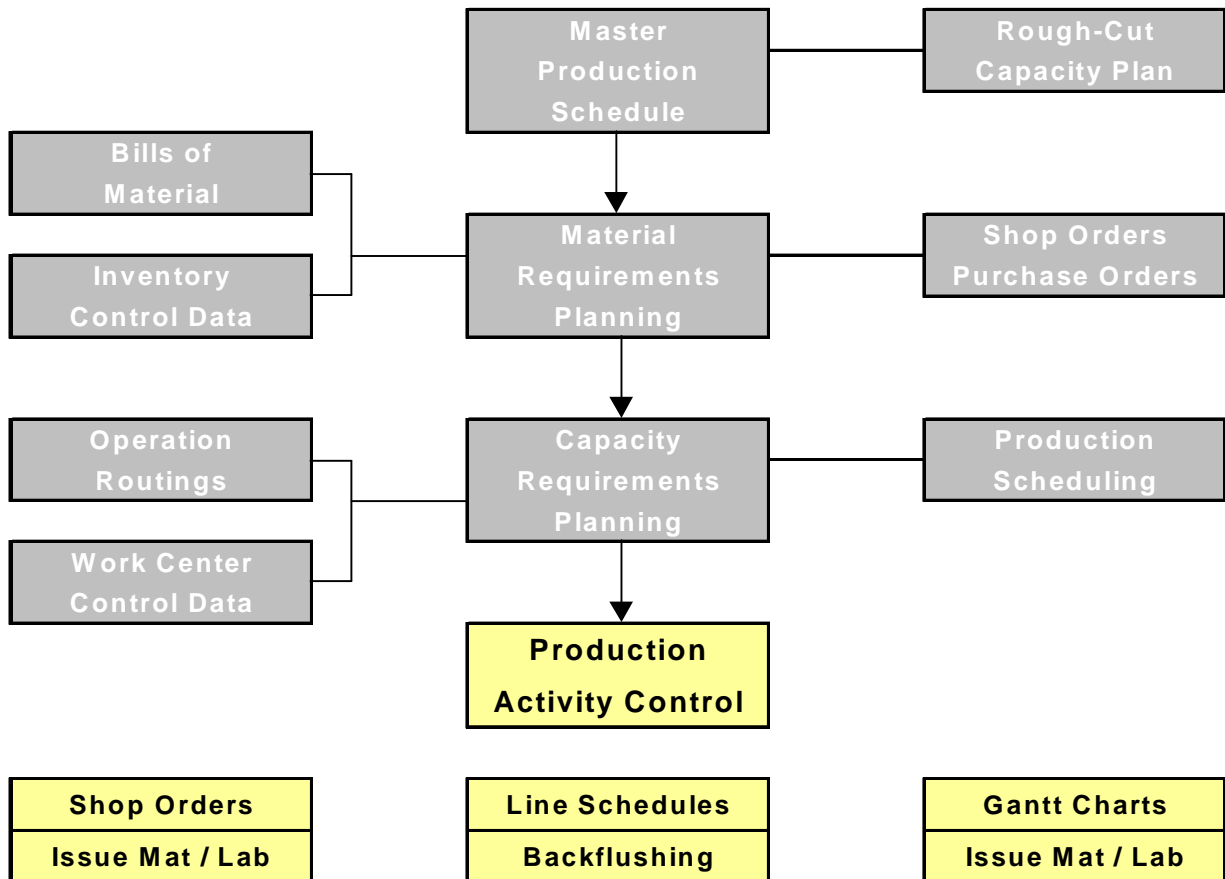
Visual Factory Utilization



Visual Production Scheduling



Production Activity Control



Purpose of PAC

- release manufacturing orders or production schedules
- issue materials consumed in the production process
- post labor time consumed in the production process
- track work in progress and report finished production
- measurements to evaluate profitability and productivity

Production Control & Analysis

Batch Lots	Flow Lines	Projects
<p data-bbox="331 495 508 531">Shop Orders</p> <ul data-bbox="250 569 570 663" style="list-style-type: none"> • resource availability • print shop order packet <p data-bbox="345 716 493 751">Processing</p> <ul data-bbox="250 789 583 951" style="list-style-type: none"> • issue materials by oper • scan / post labor by oper • report production by job <p data-bbox="334 1003 505 1039">Profitability</p> <ul data-bbox="250 1077 558 1239" style="list-style-type: none"> • sales margin analysis • plan vs actual job cost • analyze scrap by job <p data-bbox="334 1291 505 1327">Productivity</p> <ul data-bbox="250 1365 578 1526" style="list-style-type: none"> • employee productivity • machine productivity • workcenter productivity 	<p data-bbox="753 495 963 531">Line Schedules</p> <ul data-bbox="686 569 1019 663" style="list-style-type: none"> • resource availability • print work cell schedule <p data-bbox="784 716 932 751">Processing</p> <ul data-bbox="686 789 1027 951" style="list-style-type: none"> • backflush plan materials • track or backflush labor • report prod by stockcode <p data-bbox="773 1003 943 1039">Profitability</p> <ul data-bbox="686 1077 1016 1239" style="list-style-type: none"> • standard sales margins • process costing analysis • cycle count for waste <p data-bbox="773 1291 943 1327">Productivity</p> <ul data-bbox="686 1365 995 1459" style="list-style-type: none"> • <i>employee productivity</i> • <i>work cell productivity</i> 	<p data-bbox="1195 495 1382 531">Work Orders</p> <ul data-bbox="1128 569 1435 663" style="list-style-type: none"> • resource availability • provide detailed plans <p data-bbox="1211 716 1365 751">Processing</p> <ul data-bbox="1128 789 1442 951" style="list-style-type: none"> • issue materials used • post labor expended • report percent finished <p data-bbox="1203 1003 1373 1039">Profitability</p> <ul data-bbox="1128 1077 1393 1171" style="list-style-type: none"> • progress billings • plan vs actual cost <p data-bbox="1203 1291 1373 1327">Productivity</p> <ul data-bbox="1128 1365 1442 1400" style="list-style-type: none"> • employee productivity

Measuring Productivity **Efficiency** x **Utilization**

Efficiency: Standard Hours / Actual Hours

Utilization: Hours Worked / Hours Available

Principles of Inventory Management

Inventory is defined as the buffer between supply and demand.

Inventory can be the finished goods stock needed to supply the demand to fill customer orders, or it can be the raw materials stock needed to supply the demand from manufacturing orders.

This buffer costs money and detracts from net income. APICS estimates the annual cost of inventory to be 35% of a company's average inventory value. Cost of capital, insurance, storage, handling, obsolescence, deterioration, spoilage, pilferage and property taxes all contribute to the cost of inventory.

On the other hand, lost sales opportunities, back orders, freight premiums and expediting are some of the costs associated with not carrying inventory.

Inventory Management is defined as a system of material management processes that are necessary to achieve the following goals:

- optimal *customer service* (measured by delivery Service Ratio)
- optimal *inventory mix* (the right quantities of the right items at the right time, prevent material shortages and material oversupplies)
- optimal *operating efficiency* (foster manufacturing and purchasing efficiencies, including maintaining level work force requirements)
- optimal *return on investment* (is inventory the best use of capital, maximize the above stated goals while minimizing the investment)

Customer Service

Customer service is defined as the ability to address the needs, inquiries and requests from customers.

Addressing the customer's needs means providing a product or service that meets or exceeds the customer's requirements, including on-time delivery.

The ability to deliver product on-time can be measured as follows:

$$\textit{Service Ratio} = (\textit{items shipped on-time}) / (\textit{total items requested})$$

A higher Service Ratio means more satisfied customers, but at the cost of a greater inventory investment. However, it is important to note that better service to customers can out-market lower prices in many situations.

Inventory Mix

Inventory is typically classified as follows:

Raw Material – purchased material that is converted during the manufacturing process

Work in Process – partially processed items containing value-added material, labor and overhead costs

Finished Goods – the finished product that can be sold to a customer, or used as a component in a subsequent manufacturing process

Inventory items are identified and tracked using stock codes, and sometimes by a Stock Keeping Unit (SKU). Although the same stock code can be used to reference an item regardless of warehouse location, SKU codes identify an item at a specific geographic location. Therefore, a single stock code item stored at the main warehouse and at six distribution centers represents seven SKU codes.

Inventory tracking can be perpetual or periodic. Perpetual inventory means that all transactions that affect inventory are processed as they occur, so that the amount of inventory available is known at all times. Periodic inventory means that inventory is periodically counted and the records adjusted.

Material requirements planning (MRP) is the primary ERP tool used to manage the optimal mix of inventory items. A perpetual inventory is mandatory when utilizing MRP. In addition, the perpetual inventory stock status must be at least 95% accurate and the bills of material must be at least 99% accurate for MRP calculations to be effective.

The optimal mix of inventory items will also be impacted by the accuracy of sales forecasting, inventory batching rules and manufacturing lead times.

Distribution requirements planning (DRP) uses logic very similar to MRP logic and may be used to manage the optimal mix of inventory items by SKU in multiple distribution centers.

Operating Efficiency

When manufacturing or purchasing materials, it is important to consider the shop order or purchase order quantities (lot sizes).

Lot sizes that are too small may be inefficient with respect to manufacturing setup costs, or may cause the purchase price to be relatively high. On the other hand, lot sizes that are too large may cause inventory oversupplies.

Typical lot sizing techniques are as follows:

- ***lot for lot*** – order exact amount needed to supply demand
- ***fixed order quantity*** – fixed batch size quantities (possibly due to batch production, or raw materials packaged in fixed quantities)
- ***fixed period quantity*** – order in quantities needed to supply the demand for a specified time period
- ***economic order quantity (EOQ)*** – calculated order quantity where the inventory holding cost is equal to the setup cost to manufacture the items, or equal to the order process cost to purchase the items

The premise of EOQ is that inventory holding cost is only warranted when it would be more costly to manufacture or purchase items in smaller lot sizes due to the manufacturing setup or purchase order processing costs involved.

The mathematical equation to calculate EOQ is as follows:

$$EOQ = \text{square root of } (2 \times \text{annual usage} \times \text{order or setup cost}) \\ \text{divided by } (\% \text{ cost to hold inventory} \times \text{item unit cost})$$

Return on Investment

For most companies, proper inventory management has the greatest potential for improving net income. Material shortages and material oversupplies can have an enormous drain on corporate resources, and can severely affect net

income. Although inventory is a balance sheet asset, the cost of holding that asset can be very detrimental to net income on the Profit and Loss statement.

EOQ Reductions

Previously EOQ was defined as a lot sizing technique used to optimize manufacturing and purchase ordering efficiencies. The premise of EOQ also indicates that reducing setup costs or purchase ordering costs will cause a reduction in the calculated EOQ lot size, which will promote a reduction in inventory carrying costs.

For manufactured items, a reduction in EOQ lot size reduces manufacturing lead times, reduces WIP, reduces finished goods inventory, and facilitates production scheduling.

For purchased items, a reduction in EOQ lot size will tend to reduce raw material inventory levels.

Inventory Turns

The common method for benchmarking inventory investment is as follows:

$$\text{Inventory turns} = (\text{annualized cost of sales}) / (\text{current average inventory})$$

A high inventory turn rate indicates that a minimal inventory investment is being used to achieve the level of sales, whereas a low inventory turn rate indicates the opposite.

As an example, an inventory turn rate of six would indicate that inventory equivalent to only two months of cost of sales value is needed to sustain the current sales pace. An inventory turn rate of one would indicate that the equivalent of an entire year's worth of cost of sales value is being held as inventory.

Reasonable inventory turn rates are industry specific. Many companies will use the standard for their industry as a benchmark when evaluating their inventory investment using this method.

Sales Forecasting

In make-to-stock and assemble-to-order manufacturing environments, an accurate sales forecast is critical input to developing an accurate Master Production Schedule (MPS). If MPS is not accurate, then the wrong types

and quantities of product will be manufactured, resulting in unnecessary raw material, work-in-process, and finished goods inventory holding costs.

Independent demand (finished goods) should be forecasted, and dependent demand (sub-assemblies or purchased components) should be calculated using MRP.

Forecasting is not an exact process. It is usually based on sales history, seasonality considerations, market intelligence, leading indicators, trend projections, product life cycle, panel consensus, management estimates, statistical analysis, and sales commitments. Any information that can provide forecasting accuracy should be utilized.

Tracking signals are used to measure the accuracy of the sales forecast for each stock code being forecasted by measuring the deviation between the forecast and actual sales. Deviations from the forecast can be either time or quantity related.

The forecast tracking signal is mathematically computed as follows:

$$\text{Tracking Signal} = (\text{algebraic sum of the deviations}) \text{ divided by } (\text{sum of the absolute deviations} / \text{number of time periods})$$

A tracking signal that exceeds plus or minus 4 indicates a poor forecast for that stock code item.

Safety Stock

Safety stock and safety lead time provides protection against unforeseen fluctuations in supply or demand. Safety stock is used for independent demand, and safety lead time is used for dependent demand. Both safety stock and safety lead time will increase inventory holding costs.

Again, it is not advisable to hold inventory for dependent demand material until MRP calculates the need for this material. However, it may be advisable to include safety lead time for these items to compensate for poor lead time reliability.

Fluctuation in demand is known as demand variability, and is caused by variations between anticipated demand and actual demand. Unreliable sales forecasts or erratic customer buying patterns contribute to increased demand variability. Increased variability requires increased safety stock to achieve the desired level of delivery service.

Replenishment time will also affect the amount of safety stock to carry. The longer the replenishment lead time, the more safety stock is required since the window of opportunity to run out of stock is larger.

The amount of safety stock to carry for each stock code item can be calculated mathematically. The formula is a function of the variability of demand, the replenishment lead time, and the desired delivery service level.

$$\text{Safety Stock} = (\text{Standard Deviation}) \times (\text{Safety Factor}) \times \text{square root of} \\ (\text{lead time divided by forecast period})$$

The *Standard Deviation* is a statistical analysis term relating to the amount of demand variability. It can also be defined in terms of Mean Absolute Deviation (MAD), where MAD is simpler to calculate.

$$\text{Standard Deviation} = \text{MAD} \times 1.25$$

The *Safety Factor* is obtained from a *Safety Factor Chart* that defines the numerical factor to be used to attain a desired *Service Ratio* delivery performance level.

<i>Safety Factor Chart sampling:</i>	<i>Service Ratio</i>	<i>Safety Factor</i>
	80%	0.84
	90%	1.28
	95%	1.65
	98%	2.05
	99%	2.33
	99.99%	4.00

The Safety Factor Chart reveals that disproportionately greater amounts of additional safety stock will be required to realize incremental increases in delivery service performance.

ABC Inventory Analysis

The Pareto 80/20 rule generally applies to inventory management. The premise is that approximately 20% of the stock code items are responsible for 80% of the inventory movements.

Based on that premise, it is then prudent to focus inventory management efforts more intensely on those items that make up the 20%, since better inventory control on those items will have the greatest positive impact.

Most ERP systems include an automated process to categorize inventory items with an ABC code based on a combination of usage and value. The user would typically define the ABC code breakpoint, perhaps as follows:

A items – 80% of usage-value (20% of items)

B items – 10% of usage-value (30% of items)

C items – 10% of usage-value (50% of items)

Then the user would be able to selectively include A or B or C coded items when analyzing inventory. Typically A coded items would be managed more closely than C coded items.

Because of the different nature of purchased and manufactured items, it is critical that the ABC coding of these two groups of items be segregated. Otherwise, a purchased item with significant inventory movement activity could get coded as a C item due to the greater valuation inherent with manufactured items.

ABC inventory analysis is just another tool to provide a better return on the inventory investment.

Distribution Requirements Planning

An inventory management strategy may include *Distribution Centers* to store product, or to assemble product, at strategic warehouse locations that are geographically closer to the customers.

The benefits of this strategy include transportation savings, better customer service and increased selling opportunities. However, this strategy also adds additional overhead and inventory costs.

Centralized Replenishment Control: This is a *push system* that uses a distribution requirements planning (DRP) system to calculate and plan the replenishment requirements for all distribution facilities. Replenishment decisions are made by a DRP planner, and product is then *pushed* down to the distribution centers.

A DRP system can typically allocate inventory resources in the most cost efficient manner. However, this method may ignore the benefit of localized input, such as anticipated spikes in local demand. DRP systems use much of the same logic as MRP systems to review demand and then suggest replenishment orders, such as considering lot sizing rules by stock code.

Decentralized Replenishment Control: This is a *pull system* where product replenishment is planned at each distribution center. This method can more effectively consider any localized replenishment planning factors.

However, since each distribution center is responsible for ordering their own replenishment, it generally requires that each distribution center have their own planning system. The various systems may not be able to view or utilize inventory available at other distribution centers, which in turn may require greater safety stock levels at each location.

Storage Management processes are used to store and locate products in a warehouse, and generally fall into one of the following categories:

- **Random Location:** Product is stored wherever there is space, and the bin location may be recorded to facilitate locating that product as it is needed.
- **Fixed Bin Location:** Specific product is stored in specific bin locations. This is not the most efficient use of warehouse space, since bins reserved for a specific product may sit empty.
- **Zone Storage:** This is random location storage within a fixed zone location. Again, the bin location may be recorded to facilitate locating the product.
- **Point-of-use Storage:** This method provides storage of product at the point of usage to minimize the overhead of tracking and moving product. It can be used with finished goods held at the customer site under consignment, or with raw materials held at the work cell.

Transportation alternatives need to be considered for product being delivered to customers or product being shipped to distribution centers. The mode of transportation to use depends on volume, weight, value, distance and accessibility considerations.

The more common modes of transportation include parcel delivery (UPS), bus (Greyhound), air (Fed-Ex, UPS Red), truck line (TL, LTL, Reefer), water (ship, barge), railroad or pipeline.

Route Scheduling may also be relevant for certain manufacturers that are also in the business of delivering product to their customers. In this case, a route scheduling system may be used to plan the most efficient use of the company's delivery resources.

Such a system might plan the daily delivery routes for drivers relative to the orders that will be ready to ship. It may also plan the sequencing of orders to be loaded onto trucks relative to the planned unloading sequence of product as the driver makes the scheduled delivery stops.

When product is shipped using a third party transportation company, then the responsibility for route scheduling typically shifts to that third party as soon as the product leaves the shipping dock.

Principles of Just-In-Time (JIT)

“There is nothing so useless as doing efficiently that which should not be done at all.”

*Peter Drucker
Business Management Guru*

History of JIT

The original notion of Just-In-Time (JIT) was to provide the following:

- the right amount
- of the right material
- to the right place
- at the right time

This concept involved suppliers providing raw materials to manufacturers, or manufacturers providing finished goods to their customers.

JIT has evolved to represent a broader philosophy, and is defined by APICS *as the process for continuous improvement of quality, productivity, inventory reduction, and the elimination of all non-value-add activities through a team approach that encourages employee development and empowerment.*

The objective is to make JIT part of the corporate culture and work ethic, and typically includes the following goals:

- improve responsiveness to customers (better delivery service)
- improve quality of work life (better morale, less turnover)
- achieve minimum quality standards (TQM Zero Defect standards)
- improve manufacturing flexibility (flexible volume, mix, labor)
- improve asset productivity (inventory, people, machine, facilities)
- improve time management (time is money, enhance productivity)
- reduce costs without sacrificing quality (elimination of waste)

The soul of the JIT philosophy is the elimination of waste. Waste consists of all non-value-added cost elements. It may include excessive inventory, excessive manufacturing queue/setup/run/teardown/wait/move times, over-engineered product designs, defective product (scrap) or reworking, any motion or activity that doesn't add value to the product, poor selection of transportation, etc.

Enormous improvements in productivity and profitability are possible when applying JIT principles to the corporate culture. However, keep in mind that the successful implementation of JIT depends on people, not hardware or software. JIT is not a short-term fix, but a continuous improvement program that has to be actively promoted and supported by management.

JIT Techniques

Kanban: A simple *pull* system for the replenishment of components in a repetitive production line environment. It is a visual and orderless system used to authorize replenishment of more component material to production.

This technique is most applicable in repetitive production line environments where there is a level demand for the same components, where component replenishment has a short lead time, and where component replenishment can be made in small batch sizes.

The goal of Kanban is to minimize replenishment lead time, minimize raw material inventory, minimize manufacturing lead time, minimize WIP, and minimize queue space.

Kanban needs to be simple and visual. Examples of Kanban are as follows:

- Kanban square: **A** makes components for **B** and puts the parts in a designated area. As soon as **B** pulls that batch of parts from the designated area, then **A** is authorized to produce another batch.
- On an automotive assembly line, when an engine is installed onto the frame, a colored golf ball that designates the type of engine just used is removed from a packet attached to the engine and dropped down a pipe that goes to the engine supply room. The engine supply room then immediately replenishes the assembly line with another engine of the type just used.

- An outside supplier provides point-of-use delivery of components to a customer's production line. When delivering containers of additional components, the driver picks up the empty containers from previous deliveries. The empty containers automatically authorize the supplier to replenish that amount of component product.

Focused factories: The concept is to isolate engineering and manufacturing resources for a specific product family in order to allow the smaller group to focus its attention exclusively on that particular product line.

The concentration of resources on smaller family groups can usually provide superior products that are better aligned with customer requirements, and typically can be manufactured using more efficient workflow layouts.

Focused factories can be independent facilities separated geographically, or they can be profit centers within a larger organization at a single location.

Cellular Manufacturing: This concept is related to focused factories, and promotes developing families of similar parts to reduce changeovers and simplify scheduling. Production machinery can then be arranged by product family to reduce manufacturing queue time and move time.

Cellular manufacturing implies production line manufacturing. Production line manufacturing implies operation overlapping. Operation overlapping dramatically reduces manufacturing lead times by eliminating virtually all queue time and wait time. Removing queue time and wait time dramatically reduces WIP and reduces the space required to hold WIP.

Order splitting, which means running a single job operation on multiple machines simultaneously, may also be utilized to reduce manufacturing lead time, but at the expense of additional setup time.

Single Minute Exchange of Die (SMED): This is another JIT concept that stresses reducing setup time.

As discussed previously, reducing setup time allows for smaller economic batch quantities, which reduces inventory holding costs and allows for better flexibility responding to customer requirements.

Certified Suppliers: Certified suppliers implies fewer suppliers, and perhaps the ability to eliminate the need for inspection of incoming materials.

The original JIT concept of having the right amount of the right material at the right place at the right time is still of vital importance to a manufacturing operation. *Please note that lowest price was not part of the JIT statement.* It is very possible for lower priced components to add significantly more cost to manufacturing by generating more scrap / rejects / rework, forcing changes to the production schedule, etc.

The primary objective of a certified supplier program is to find a single source for each component, where that source can continuously meet the manufacturer's volume and quality requirements. This typically can evolve into a very close relationship where the supplier may be included in product development discussions to provide additional expertise.

Supplier certification can also apply to outside contractors who may be used to provide specialized manufacturing processes, or to provide additional capacity periodically.

As always, the JIT goal is to implement processes that allow manufacturers to operate more productively and more profitably.

Poka-yoke: This is a Japanese term meaning to mistake-proof processes, and typically includes some sort of pass/no-pass quality control check.

It implies being able to screen products from advancing in the production process if they don't pass a specific quality control test. The test needs to be simple and visual (or auditory).

Examples might be checking that the piece fits in a quality control jig, that a dowel turns easily in a hole, that the weight or temperature of the product is within a specified tolerance, that the part mates with the next part in the assembly, etc.

Theory of Constraints: This relatively modern theorem states that the throughput (productivity and profitability) of a manufacturing enterprise is restricted by the most constraining bottleneck in the manufacturing process.

The theory further stipulates that conventional cost analysis does not effectively consider the implications of these constraints. For example, if throughput is constrained at a work center that can process 100 pieces per hour, it may seem cost prohibitive to do operation splitting using an alternate work center that can only process 20 pieces per hour.

However, the improvement in total factory throughput by utilizing the alternate resource can be tremendous in such a scenario. It may allow other work centers to operate at a higher utilization, substantially increasing production for current sales orders, and significantly increasing profitability.

A technique called Drum-Buffer-Rope (DBR) has been prescribed by the Theory of Constraint (TOC) experts to maximize production throughput by paying special attention to bottleneck work centers.

DBR specifies that the constraining work center should always be operated at full utilization and that production at upstream and downstream operations should be synchronized with the production capabilities of the bottleneck work center.

To maximize the productive capacity of a constraining work center, efforts should be made to reduce setup time and tear down time, and to maximize run time cycle rates. Downtime must be minimized, and there should always be a queue of available work for this work center.

Benefits of JIT

Since JIT is a commitment to continuous improvement, the benefits from implementing JIT concepts are generally ongoing and incremental. The objective is to institute processes that promote lasting productivity and profitability enhancements. These enhancements are typically the result of numerous improvement activities, and it may be difficult to analyze the ROI from any individual activity.

Some of the benefits of operating more efficiently include the following:

- reductions in purchasing and manufacturing lead times
- reductions in raw material, WIP and finished inventory
- reductions in scrap, rejects and reworking
- reduced space needed for WIP and inventory
- setup time reductions and improved cycle rates
- improved machine and employee productivity

Utilizing JIT principles is a low risk / high reward proposition. The cost of JIT is in the education and training needed to develop personnel to be more effective in defining and implementing improvements to your operations.